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ABSTRACT

This report summarizes the findings and describes the products of a 2-part research project that examined the parameters of Washington's interlibrary loan cooperation statewide, and developed a set of computer models to be used in simulation studies of associated activities and policies. It contains a statement of the problem; an historical review; a description of methodology; a review of the findings of a statistical analysis conducted on interlibrary loan data; a discussion of the roles of an institution as a library and as a switching mechanism; explications and descriptions of the computer models and simulations; copies of the programs and portions of the printed output; and a bibliography listing 87 sources. It also provides a users' manual for the application of the models to simulate an institution's borrowing and lending activities for service planning and policy modification. (Author/FM)

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a network management tool:

computer simulation of interlibrary lending

I: The Report

by
Hugh T. Vrooman
Mary Jane Pobst Reed

A Report to the
United States Office of Education
under the
Library Research and Development Program

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FOREWORD

This report has been made possible by the cooperation of many librarians throughout the state of Washington who extended their own and their staffs' efforts to provide data as requested. A special note of appreciation must go to K. J. Gesterfield, Director of the Illinois State Library, for her understanding, cooperation, and support, and to R. G. Swartz, Washington State Librarian.

This study has been sponsored by the Washington State Library and funded by the United States Office of Education - Library Research and Demonstration Program under the Higher Education Act of 1965 - Title II-B. Henry Drennan, as USOE project officer, facilitated procedures and offered valuable encouragement. The findings and recommendations of the report are those of the investigators and are not necessarily those of the Washington State Library or of the United States Office of Education.

ABSTRACT

This report summarizes the findings and describes the products of a research project that examined the parameters of the borrowing/lending aspect of Washington State interlibrary cooperation and developed a set of computer models to be used in simulation studies of associated activities and policies.

It contains a statement of the problem set as defined to place bounds on the scope and depth of the research; a statement of historical content; a description of methodology; a review of the findings of a statistical analysis of data concerning borrowing/lending, transaction success and turnaround time as well as a discussion of the roles of an institution as a library and as a switching mechanism. Also included are explications and descriptions of the computer models and simulations along with copy of the programs and portions of the printed output. Recommendations are presented and their premises discussed. A select bibliography is appended to Part I.

Part II is a users' manual for the application of the GPSS models to simulate an institution's (individual library or network) borrowing/lending activities for service planning or procedure/policy modification.

SUMMARY OF RECOMMENDATIONS

1. It is recommended that planning be immediately begun for a statewide interlibrary borrowing and lending policy review within the context of budget support and role in library service programs. A finding of this study indicates that roughly 25% of circulation funds are used to support interlibrary lending which accounts for approximately 0.4% of circulation activity.

2. It is recommended that planning be started to train all interlibrary loan initiating staff to determine item location and call number before placing requests into the system.

   Requests should always be sent directly to owning institution. Only if owning library location is unknowable should a locator/switching center or another library be accessed on speculation of success. A study finding indicates that known location shortens the turnaround cycle by at least a day, and fill rate is improved by 25%. Cost is reduced by the request's being processed fewer times. In Washington, with access to both electronic and hard copy versions of the Resource Directory which contains locations for most post-1973 materials, and the 40-year-old PNBC union catalog with five states and British Columbia location data, it would appear that most requests for recent materials could be sent to a known location. If a library lacks the appropriate location tools it would be good strategy, dependent on publication date, to direct the request to either of the two major switching centers, the State Library or PNBC. Of course if the PNBC union catalog is eventually contained in the WLN data base, PNBC's mission will undergo modification for its present reason for existence will tend to disappear. Since a major portion of both WSL and PNBC traffic is interlibrary loan dependent, it would appear profitable for both to examine procedures rigorously. Turnaround time for PNBC averages 7 days, while WSL's time is two days shorter.

3. It is recommended that no request be sent to more than three locations. Only an additional 2.8% of requests were filled at the 4th and 5th referral. Each referral, it is indicated, adds an estimated $6.33 to the total cost of the loan.

4. It is recommended that all unverified and unlocated owner requests from libraries equipped with adequate bibliographic tools be returned without processing. A large number of requests analyzed during the study remained unfilled because of poor citations.

5. It is recommended that policy concerning subsidies for interlibrary loans be examined. Present reporting procedures for data concerning subsidies appear less than adequate. The precise nature of what is now being counted and how is often uncertain. An added criterion for subsidy qualification could be a time-based success factor.

6. It is recommended that all Washington institutions be encouraged to quantitatively analyze all processes associated with interlibrary loan fulfillment and to develop quantitative decision instruments for the rational management of this service as a device for improving the cost/benefit ratio. Use of the models developed during this study to test procedure modification and optimize staff utilization should also be advocated. The co-directors of this project will assist users during the six months immediately following report production.

7. It is recommended that PNBC examine its union catalog policies. Duplication in the union catalog of items being input to the WLN data base should be avoided. Access to these items by PNBC staff can be had in a computer display terminal.

8. It is recommended that PNBC's union catalog be examined to determine authenticity of its holdings records. PNBC does not knowingly forward requests to institutions that do not own requested items. This study indicates, however, that 64.5% of the requests unfilled by the first referred library after PNBC were not filled because that library did not own the item. It appears that a significant amount of the data in PNBC's union catalog is no longer accurate. Decision to input the union catalog to the WLN data base should be delayed until a quality improvement process is developed.

9. It is recommended that an holistic approach be developed for the common problems associated with the concepts of resource sharing, remote storage, interlibrary cooperation, and service programs. A quantitative analysis and computer simulations can provide input for enhanced objectivity in the decision process.

10. It is recommended that a workshop to present the techniques used in this projects to the Washington library profession be authorized. The material would be presented at both the management level and the technician level.

PREFACE

This is the final published report of research being carried out at the Washington State Library to design and utilize computer models of both statewide interlibrary lending activities and internal institution interlibrary loan request processing.

This project follows on work done under a previous grant from the United States Office of Education which explored the feasibility of developing computer models for optimizing site locations and procedures for mail order and delivery of library materials. A basic goal of the present project is the development of models that will allow interlibrary lending related policies and decisions to be tested and results obtained in a laboratory mode prior to selecting the optimized policies and decisions for implementation in the real world. The project staff worked under the monitorship of Roderick G. Swartz, State Librarian. Mr. Swartz is actively involved in the development of an improved interlibrary lending system for the State of Washington and acted as a surrogate reviewer for the Washington library community with respect to much of the research carried out within this project.

The major thrust of the research activities during the first half of the project involved the development of a project research plan, a literature search, the design and implementation of a data collection system, reduction and analysis of data, and development of model concepts. These activities are described in later sections of this report.

Statement of Purposes

This applied research project investigates interlibrary lending protocols and procedures and develops devices by which selected alternatives relative to the processing of interlibrary loan requests can be evaluated. This is being done with the aim of providing library managers with richer data to be used in optimizing decisions in a network context.

The problem is how to evaluate various interlibrary loan system configurations and policies, without the disturbances and costs in time and money of real world implementation.

The original plan was to develop two inter-related computer models, virtually two machines simulating the action of interlibrary loan operations, incorporating parameters representing political, environmental and procedural decisions as well as traffic and efficiency dynamics. The models were to describe the relative connection between network component institutions and intra-institutional processing formats during interlibrary loan activities. In actuality, five models were developed.

Project Activities

October 1977:

A. Development of a project research plan

1. specify problem
2. determine what is needed to arrive at solution
3. look at other work elsewhere, determine what is available and pertinent
4. decide what data is needed to develop the solution
5. design data collection system
6. decide on techniques for analysis
7. establish techniques to evaluate data on hand against what is needed
8. techniques for improving data collection and evaluation as necessary
9. establish benchmarks of validity and procedures for validation of models
10. techniques for evaluating utility of models
11. techniques for application of models to test present and proposed policies and systems of component relationships
12. modes of analysis of simulation
13. techniques for determining implications of analytic results and formation of recommendations
14. lay out scope and procedures for writing report and develop user operation manuals for computer simulation models
15. structure report distribution and presentation
16. development of program for communication of utility of project products and their continued application and use

B. Literature search

A literature search was undertaken as an early step in the project. While the writings on interlibrary lending are voluminous, little activity is reported in computer modeling.

Two outstanding examples reported in the literature are the work of William and Sandra Rouse and that of the Allen Kent team at the University of Pittsburgh. The Rouse model at the University of Illinois was designed to address a different set of problems from the present research. The work of James Williams on the Kent team, because of its sophisticated statistical underpinning is more germane to the present work. That team's work, however, deals primarily with resource sharing, while the present research deals with resource sharing in the interlibrary loan milieu.

Especially pertinent to the present study is the writers' own work in 1974, providing a generalized computer model for mail order and delivery of library materials.

October/November:

Design and implementation of data collection system.

After ruminating upon the research problems faced and the possible mechanisms for solution, the set of data describing the universe of this research was decided upon and sources and methods of collection were defined.

Initial collection efforts entailed telephonic communication with 82 libraries. This data was used in a Bayesian probability approach to an understanding of the research universe. In other words, information about the environment that was learned in each phase of the study was used to refine the succeeding phases. This approach cycled through three separate preliminary analyses before development of the ultimate sampling pattern and of the technique for computerized processing of the statistics. This increasing understanding builds greater confidence in the validity of assumptions made about the components, relationships, and boundaries of actions that describe the libraries and protocols and systems of resource sharing in Washington State.

Several factors influenced the final selection of sample size. The major factor of course was the confidence level of the analytic outcomes, but serious consideration was also given to minimizing the cost of data redcuction and examination.

In addition to the initial telephonic data collection effort, there were three subsequent data collection events of quite different natures: 1) an audit trail for each interlibrary lending request that was initiated between November 1 and 11, 2) in-depth on-site interviews at 20 libraries during February and March, and 3) inquiries for resource description to 331 libraries, in March.

November/December/January:

Collection and analysis of data.

January/February:

Collection and analysis of data.
Computer models concept definition.

March:

Collection and analysis of data.
Computer models concept development.

April:

Collection and analysis of data.
Models redefinition and redesign.

May:

Data Analysis.
Final models design and programming.

Finalize format of final report; assign segments for writing; plan presentation of results to library community.

26-30 - inputting and debugging of models.

June:

Validation of models.
Initial simulation runs.

July:

Analysis of output.
Additional simulation runs and analysis.

August:

Develop models to compare WLN data base organization with other data base organization types.

September:

Simulations and analysis.

October:

Simulations and analysis.

November:

Report writing.

December:

Simulations and report writing.

March 1979:

Final model modifications, simulations, analyses, report writing and production.

As part of the original research plan, a set of control mechanisms was devised for project management. These included estimates of time for each project process component and the division of all such components into limited-duration tasks. That is, all tasks were designed to be accomplished in two weeks or less. If a task appeared to occupy more time, it was re-examined and broken down into smaller components. This allowed the unit of progress to be defined and operated as the man-week, which in the given circumstances allowed frequent and easy checks in production.

The greatest inhibition to schedule adherence proved not to be misevaluation of task time, but the responsibilities of the research team's regular positions.

A problem that was foreseen and therefore planned for was the inadequacy of response from some sources to requests for data. This necessitated the identification of these sources and repeated contact until data of appropriate quality was obtained.

Misunderstandings concerning the research products became evident shortly after the intial data collection effort began. Much of this misunderstanding seems to be motivated by fear of technologic solution and a lack of faith in the utility of research. Some problems of an opposite nature arise from the assumption that technology and science can provide magic answers to problems that people have been unable to define sufficiently to develop solutions of their own. To respond to this situation, a program of memoranda, personal contact, and public explication was instituted, including informative reports to the Washington Library Network's Executive Council and to its Resource Sharing Task Force. This program should culminate at the project's completion with a large-scale effort to foster understanding of the research and ongoing use of its products.

It is hoped that this effort will take the form of a three-day meeting for Washington library managers, during which they will be addressed for one day by national experts in operations engineering and research; on the second day the rationale and utility of the models will be discovered to them; and the third day will be a workshop of hands-on operation, evaluating the managers' own policies and decisions. The aim of this program is to develop a level of competence in these managers so that continued use will be made of this research's products.

INTRODUCTION

This project addresses the task of evaluating present and alternative interlibrary loan protocols and procedures with the goal of providing optimum services at lowest cost. A comcomitant task is to provide library managers with tools for ongoing analysis.

At present, under what are considered severe fiscal restraints, librarians are reluctant to spend large segments of budget on materials, preferring to spend on staff and to rely on resource sharing for supplying some information needs of users. At the same time, librarians are increasingly aware of the costs of interlibrary loans, as lenders install (or threaten to install) borrowers' fees. It has been hypothesized by some researchers that there is a break point where cost of interlibrary loan is greater than cost of purchase.

The situation poses a number of questions: Is interlibrary loan a feasible way of sharing resources? Has sharing increased? Have budgets become more restricted? Are more borrowers' fees being charged? What portion of service costs can be ascribed to interlibrary loan? What portion of services? What have been the changes in protocols?

This study attempts to consider such questions and to provide a perspective for evaluating the resource sharing situation. Interlibrary loan in the state of Washington serves as the prototype investigated.

The report is organized into two parts; the first part contains six sections. The first section gives a brief historical review of interlibrary loan in the United States; the second describes the situation in Washington State, and the third describes this study's data collection and analysis methodology. The fourth section discusses statistical findings, the fifth describes the models constructed, and the sixth offers recommendations. The second part is a manual to assist in adaption, operation, and interpretation of the manuals.

HISTORICAL ASPECTS OF INTERLIBRARY LOAN

Although in Europe the lending of materials between libraries had been customary for some time previously, in the United States the concept seems to have been first publicly advanced by Samuel S. Green, librarian of the Worchester (MA) Free Public Library. The first issue of Library Journal (September 1876) carried a suggestion from Green that librarians might wish to rely on institutional rather than individual responsibility for loaned materials; prior to that time, any loans beyond a library's own user community had been made directly to requesting individuals.

By 1891 Green, in his presidential address at the annual American Library Association's Conference, could mention the institution of specific mechanisms for interlibrary lending at the Surgeon General's Library in Washington; he also discussed other pioneers in this activity such as the Boston Athenaeum, the Boston Public Library, and Harvard, Yale, and Columbia libraries. However, in Library Notes for July 1892, Melvil Dewey with a fine display of professional contrariness and caution noted:

> "Inter-library loans which wer a litl while ago almost unknown ar now of daily occurence. The spirit of helpfulness and wish to hav the library used is in the ascendent. We ar, and hav been from the first, ernest champions of this, but a note of warning is needed. In their zeal to serv one, sum libraries are abusing the rights of many. Trying to be useful to scolars who can not afford to cum to the library they sumtimes simply encurage indolent and presuming selfishness."[1]

The growth of concern for interlibrary loan can be traced through Library Literature. During the 28 years from 1921 (four years after the first ALA code for interlibrary loan practice was promulgated) through 1948, a total of 156 items were indexed--most of them how-to articles. During the next 28 years, 1949 through 1976, 841 items are indexed, more than five times the previous period, with a strong trend toward surveys, cost and time analyses, policy discussions, and reports of network developments. The magnitude of recent concern may be indicated by the fact that the 141 items listed in the latest two-year cumulation (1974-75) equal 90% of the total number of items indexed in all the 28 years before 1949.

As for tracing the growth of interlibrary traffic, a literature search on the subject reveals no coherent body of facts from which principles

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[1]Library Notes, 3, July 1982, pp. 405

can be induced. Descriptive statistics for libraries as collected and reported are seldom of much utility for inferential work because of the lack of explicit details concerning what the data actually represent and what sorts of clumping if any have taken place. Comparable variables, time periods, samples, or data collection techniques almost never occur, so that studies neither support nor refute one another, but stand as separate sets of findings. (Caveat lector when reviewing published library statistics.) Where a study's results can be compared with those in the present project, those results are mentioned in the appropriate context of this report.

A comparison of two earlier surveys can be offered, since both seem direct and uncomplicated and the outcome brings into question some current impressions. Thomson (76)[2] reported for 1963-64 a total of 845,484 interlibrary loans for 1,914 academic libraries. The U.S. Office of Education's figures for 1972-73 give 1,771,764 interlibrary loans for 2,846 academic libraries--Thomson's is an average rate of 442 loans per library annually, while the USOE's is 623. While this is a substantial increase--40% over a nine year period--it is somewhat less than academic librarians would have the profession believe.

Comparisons of cost reports in the literature are as suspect as are other statistical reports: iterum caveat lector. Table 1 shows cost calculations which have been published during the 1970's. NELINET findings in 1977, based on total costs and traffic reported by participating libraries and carefully standardized by NELINET and (corroborated by the King findings) were selected as the basis of our costing estimates.

[2] Figures in parentheses refer to items in the bibliography.

TABLE 1

COST CALCULATIONS*

RESEARCHER	DATE	SAMPLE	BORROWING	(BOTH)	LENDING	FILLED	UNFILLED
Nelson Assoc. (40)	1969-70	New York State ILL		$ 5.87			
Palmour (51)	1972	67 main libs. 73 branch libs. for ARL	$ 7.61		$ 6.39- 5.82	$ 4.67	$ 2.12
Crossar (70)	1972	Trent University	4.28		2.14		
Univ. of Toronto (70)	1971-72	U.T.				lend 4.94 borrow 15.45	6.59 3.23 forwarding cost 3.77
Univ. of British Columbia (70)	1972-73	U.B.C.				lend 2.50 borrow 8.18	2.11 6.99
Hayes (17)	1973	Palmour (37)		8.77			
West (83)	1973	8 academic lib.	6.49		6.49		
King (24)	1976	Journal requests	10.02		7.27		
WICHE (72)	1976	28 academic		2.97- 3.65			
		45 public		1.10- 3.72			
		10 state libraries		4.08			
King (23)	1977	Westat study (journals)	8.98		6.87		
NELINET (42)	1977	51 academic	5.12- 11.40 mean=		4.08- 10.52 mean=		
		5 public	8.36 $9.91		6.85 $7.83		
		8 special	11.32		7.55		

*Not adjusted for inflation from original requests.

INTERLIBRARY LOAN[3] IN WASHINGTON STATE

The state of Washington is served by more than 2,000 libraries--public, school, higher education and special (see Table 2). There are no official restrictions on who may use interlibrary loan or what types of materials may be requested; the only restraint is the initiating librarian's and patron's common sense.

A union catalog of the major libraries of the Pacific Northwest, including Alaska and British Columbia, is operated by the Pacific Northwest Bibliographic Center (PNBC) from its offices in the University of Washington library. This catalog enables PNBC to be a regional switching center for interlibrary loan.

The Washington State Library (WSL) and the University of Washington (UW) are the main loan sources within the state. The computerized data base of the Washington Library Network (WLN), accessed by on-line and microfiche devices, is a partial union catalog of the participant institutions, containing holdings records for current acquisitions since 1972. One of the effects of WLN has been the dispersal of interlibrary requests to more of the smaller libraries, as predicted by Dougherty (13), and reported by Kilgour (22). According to a study for California State University and Colleges (83), fewer referrals are necessary when owning libraries are identified. While the concomitant increase in number of requests may not permit reduction of staff, more requests should be processed by the same size staff.

Table 3 shows public monies spent on libraries in Washington. For higher education libraries the earliest available figures are for 1972-73; for public libraries we have figures for 1967. Applying the Consumer Price Index of the U.S. Bureau of Labor Statistics, we see that libraries have not experienced a diminishment of real dollar support. In fact, community colleges and public libraries now receive more real support than in the prior years cited, while public colleges and universities receive only 2% less than earlier.

Table 4 lists subsidies (from Federal funds) to four public libraries which are net lenders,[4] and Washington's share of PNBC expenses. Major academic net lenders are not subsidized, since they are already state-supported institutions. Table 5 shows estimated borrowing activity by type of library.

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[3] Interlibrary loan activity in this study does not include transactions within a district library system; it is only inter-system or library activity.

[4] An institution that lends more items than it borrows via interlibrary loan.

The perspective of costs and activities for interlibrary loan against total circulation is set by using Mosley (35)--$0.45 per regular circulation (adjusted for inflation on basis of Consumer Price Index)--and the King/NELINET cost calculations. Given this study's average of 1.4 libraries handling each transaction, each interlibrary loan transaction incurs a cost some 60 times that of a regular circulation transaction.

While an unfilled request would cost less than the NELINET figure (that study seems to reflect only filled requests) because materials are not transferred, requests to more than one library would cost more than reported by NELINET. A reasonable and conservative estimate based on the NELINET figures, would be $26 for filled and $23 for unfilled requests, considering that each request is referred to an average of 1.4 libraries, and adding 10% for inflation (Table 6).

Annual circulation for Washington libraries in 1977 is estimated at 27,000,000 and total interlibrary loan requests at a rounded 167,000: 140,000 filled and 27,000 unfilled requests. Cost of circulation at $0.45 is an estimated $12,150,000; cost of interlibrary loan is estimated at $4,261,000. In other words, 0.5% of circulation is absorbing 35% of circulation expenditures. Library type segments and individual components of the whole informal network demonstrate a similar pattern: community colleges (net borrowers) incur costs of $400,000 for circulation and $125,000 for interlibrary loan so that 0.2% of the activity is absorbing 31% of expenditures. The University of Washington (a major lender) tallied interlibrary lending (including out-of-state) as 1.4% of the total circulation, yet costs amount to $172,000 per year: 40% of total circulation costs of $387,000.

It can be seen that we are studying a small segment of library service in terms of activity, but one which absorbs a disproportionate share of library budgets. Melvil Dewey's cautionary note bears repeating: "...In their zeal to serve one, some libraries are abusing the rights of many...they sometimes simply encourage indolent and presuming selfishness...we foresee abuses that make it necessary to watch carefully lest we serve one at the cost of many." Interlibrary loan may have become the tail that wags the dog.

Table 2

LIBRARIES IN WASHINGTON STATE, 1978

Library Type	Number	Subtotals
Universities and colleges		
Public [1]	6	
Private	12	
Community Colleges	27	
		45
Public Libraries and District Libraries [2]		
Serving more than 100,000	12	
Serving 25,000-100,000	8	
Serving 5,000-25,000	17	
Serving fewer than 5,000	41	
		78
Special Libraries [3]		
Federal	29	
State	46	
Medical	49	
County Law	39	
Newspaper	12	
Business and Industry	42	
Other	10	
		217
Schools K-12 (est) [4]		1,700
		2,040

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1 The oldest and largest academic collections are held by the University of Washington (UW) and Washington State University (WSU).

2 Fourteen districts encompass 120 libraries (counted here as 14); member libraries in each district are organized into a library system. Fifty-eight public libraries are not members of any system, and six club and privately supported libraries offer public services.

3 Special libraries vary greatly in size, with Boeing and Weyerhaeuser companies the most active in interlibrary borrowing.

4 School libraries' participation in library loans is negligible.

Table 3

PUBLIC FUNDS FOR LIBRARIES IN WASHINGTON STATE [1]

	1977-78	Prior Year	Ratio[6]	CPI[7]
6 public universities and colleges	$16,971,000[2]	$11,700,000 (1972-3)	1.45	1.48
27 public community colleges	6,920,500[2]	4,000,000 (1972-3)	1.73	1.48
78 public libraries	31,670,188[3]	11,155,000 (1967)	2.84	1.81
State Library	5,929,987[4]	Not comparable[5]	----	----
	$61,491,675			

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1 No figure available for public schools.

2 For fiscal year 1977-78, from State of Washington Pocket Data-Book, 1977.

3 For calendar 1977, from Annual Statistical Bulletin, 1977, Washington State Library, 1978. Includes capital expenditures.

4 Actual expenditures, 1977-78.

5 Inclusion of WLN development and operational costs in the WSL budget precludes comparison.

6 1977-78 figures divided by prior figures.

7 Consumer Price Index shift for same period.

Table 4

WASHINGTON STATE FUNDING OF INTERLIBRARY LOANS

(1978 payments based on 1977 figures)

October 1977 Figures

Library	Lent		Borrowed	Ratio	Net Lending	Received	Rate per Net Loan
Seattle PL	3,639		1,838	1.98	1,801	$ 35,000	$19.43
	+ 2,540	- King County Library System					
	+ 2,248	- Special, Science Reference					
Spokane PL	5,056		1,973	2.56	3,083	15,000	4.87
Tacoma PL	+ 2,886	- Weyerhaeuser and Pierce County Library[1]	1,796	1.61	1,050	15,000	14.29
Everett PL	1,287		407	3.16	880	4,500	5.11
					6,814	$ 69,500 Average = $10.20	
To PNBC - 51,062 requests from WA 77-78						$190,300 Average = $3.73	
Less $54,000 non-public monies to PNBC						54,000[2]	
Less $40,000 state funds						40,000[2]	
Total						$ 96,300	

[1]Weyerhaeuser phones reference librarian; Pierce County takes directly from shelf.

[2]$54,000 from business and industry, $40,000 from state funds, remainder federal funds.

TABLE 5

ESTIMATED WASHINGTON STATE INTERLIBRARY REQUESTS* 1977-78

Type of Originating Library	Annual Requests	% of Total ‡	% Filled θ	Filled Requests
Academic §	34,200	20.5	91.9	31,400
Public	96,200	57.6	78.6	75,600
Special	34,900	20.9	85.7	29,900
WSL	1,700	1.0	98.0	1,700
Total	167,000	100.00	83.1	138,600 @

* It should be noted that any particular request may be referred to more than one library and that the mean is 1.4 libraries per request.

§ Throughout the report, academic includes public and private universities, colleges, and community colleges, unless otherwise specified.

‡ Percentages derived from 304-case sample.

θ From 304-case data (except WSL which was 100% for 49 cases and arbitrarily reduced to 98%)

@ Alternative Network Study (81) gives a total of 55,800 in 1969; 267% increase in 8 years.

Table 6

COST CALCULATION FOR
INTERLIBRARY LOAN TRANSACTION

	Filled Request	Unfilled Request (no delivery)
Borrowing Library*	$ 9.91	$ 8.41
Lending Library*	7.83	6.33
+ .4 Borrower (no delivery)	3.36	3.36
+ .4 Lender (no delivery)	2.53	2.53
Total	23.63	20.63
Inflation factor	1.1	1.1
Adjusted total	$25.94	$22.70

*NELINET data.

DATA COLLECTION AND ANALYSIS

The study used four separate modes to gather data. First, a telephone survey was completed in October 1977. When it became apparent that the data which libraries could supply from their own records was less than was needed, the second mode was introduced: the collection of all interlibrary loan requests originating in the state during the first two weeks of November. Later, a questionnaire was administered to gather data on collection strengths. Finally, to acquire data for constructing the model of internal interlibrary loan procedures, site visits were made to 20 selected institutions throughout the state.

The October telephone survey encompassed public and private universities and colleges, community colleges, selected school and special libraries, and public libraries serving more than 5,000 population--a total of 119 Washington libraries. Data were gathered on month-by-month interlibrary lending and borrowing, the locations to and from which requests were routed, photocopying activity, total circulation, ratio of rush requests, and ratio of borrowing requests filled at the first requested library. (See memorandum of 5 October in Appendix A.)

Analysis and a first cut computer model indicated that additional data was needed. Consequently, plans were made to trace all interlibrary loan requests originating in the state during the first two weeks of November. Special forms to be attached to regular interlibrary loan request forms were sent to 376 libraries. These paired forms were collected, numbered in sequence and a random sample drawn. A total of 8,183 forms were received by the investigators, representing 138 libraries (see Table 7). One of the 14 district library systems failed to participate; statistical techniques were used to compensate. The data entered into the computer for each request are listed in Table 8.

A shelflist count was gathered by questionnaire, with the intention of predicting success of alternative request routes. In the event, the holdings data were too crude to fulfill the intent; a more refined technique was indicated, for which there was neither money or time.

The final mode of data collection was site visitation to 18 libraries throughout the state, plus the State Library and PNBC. Information concerning interlibrary loan policies, protocols, processes and costs were charted. These data were of high utility in constructing computer models of intra-instititution operations.

A sample of 304 cases was drawn from the request universe, on the basis of a random number table. Additionally, 12 data files were constructed for all requests originating in each of 12 selected libraries. For some computations when the procedure would not produce statistical bias, the 12 individual library data bases were merged with the random sample for a total of 1,496 cases.

As analysis proceeded, using mainly the statistical routines from the widely available computer program package called Statistical Package for the Social Sciences (SPSS), it became necessary to apply coordinate indexing methods to the computer output to control and facilitate access to the processed data for final interpretation.

Throughout the study period, communications with the profession as a whole and to selected policy bodies was maintained via memo, telephone and in-person information reports.

TABLE 7

LIBRARIES IN STUDY

	Total Number Receiving Report Forms	Number Originating Requests in Sample
Community Colleges	27	20
Public Colleges & Universities	6	6
Private Colleges & Universities	12	10
Independent Public Libraries	20	15
District & Municipal Libraries	17	15
Small Public Libraries (less than 5,000 population)	42	9
Medical Libraries	49	21
Business & Industry Libraries	42	14
U. S. Government Agencies	21	7
Washington State Agencies	12	6
Washington State Institutions	34	12
County Law Libraries	39	0
Newspaper Libraries	12	0
Other Special	11	1
School Libraries	31	1
Washington State Library	1	1
Totals	376	138

TABLE 8

REQUEST PARAMETER CATALOG

Supplied by data on request forms:

- Rush or not
- Publication date
- Fiction or not
- Classification
- Serial or monograph *
- Periodical or not
- Government document or not
- Rare or not *
- Technical report or not *
- Medium of material
- Patron type *
- Recreational or educational purpose
- Requesting library location
  - east or west of mountains
- Requested source location
  - east or west of mountains
- Number of requested sources
- Known location or not

Supplied by requesting library:

- Name of requesting library
- Branch library origin or not *
- Date of patron request
- Mode of transmission of request
- Date transaction was concluded
- Whether filled or unfilled
- Photocopy or original material supplied
- Mode of transport of material
- Date patron received item or request was cancelled

Supplied by each responding library:

- Name of responding library
- Date of receipt of request
- Whether verified by responding library *
- Response date
- Whether filled or reserved or not filled
- Reason for not filling

* Parameters marked with an asterisk proved to be not clearly identifiable or contained too few cases to permit statistical analysis with appropriate confidence levels.

STATISTICAL FINDINGS

Borrowing Patterns

The 304-case sample described above actually provides a different size sample for each parameter in the total catalog, with most samples above the 95% confidence level. The 304 requests in the sample originated in 65 libraries (see Table 9) in quantities ranging from 1 to 73 requests per library; the average number of requests per library was 3.6. The three libraries submitting the greatest number of requests were public district libraries representing 26, 25, and 40 local libraries respectively.[5]

The second part of Table 9 shows the number and ratio of each type of requesting library in the sample and the portion of requests originating from each type. It is interesting that colleges and universities (including small as well as large institutions) comprise only 16.9% of originating libraries, and submit only 16.0% of all interlibrary requests. If this ratio holds for other states, this raises a question: is the national bibliographic network being designed primarily for research libraries, and if so should this be the case?

Data for each reliable request parameter are given in Table 10; where statistical tests have shown no bias to be introduced, the selected sample of 1496 cases have been utilized. The values of discrete variables have been listed as proportion of total cases. As in most tables reported, no count is indicated for missing data, since this will not add useful information.

A typical request will be non-rush, and will request a non-fiction printed item, not a periodical or government document, which has been published within the latest 10 years. The Dewey classification of the requested item is more likely to be in the 600's or 300's than in other categories. The request will probably originate in a public library in western Washington, travel by mail to the State Library and be filled from there by a mailing of the original material. Ownership of the item is probably not known to the requesting library.

It is instructive to look at some of the differences among types of libraries; Table 11 shows the same parameters as does Table 10, with values given by type of library. The parameters marked with an asterisk are those with statistically significant differences among types of libraries (better than .05 in a chi-square test).

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[5] The district library submitting the largest number of requests achieved only a 73% fill rate as against the state average of 83--86.4% if that library is not included.

The academic library category includes community colleges and public and private colleges and universities. The public library category includes large systems, municipal libraries, and small public libraries. Special libraries include business and industry, health sciences, newspaper, law, governmental (county, state, federal) libraries, etc.

The State Library's outgoing requests (3 in the sample) are not included in Table 11. WSL is a special library in that it serves state government and it is a public library in that anyone may walk in and use the collection. Also, its function as a switching center for interlibrary loan in the state makes it different from the three categories in the table. In general throughout this report, it is treated as a unique category, as is PNBC which has no collection of its own.

A typical request from an academic library will be non-rush, and will request a photocopy of a non-fiction periodical article, not from a government document, which has been published in the latest 10 years. The Dewey classification is most likely to be the 600's though here there are too few cases for reliability. The request will probably originate on the west side of the state, will not indicate a known owner of the material, and will be sent by mail to a location west of the mountains--most likely to WSL, secondly to PNBC or to an academic library. It is likely to be filled by the first requested source, and the item mailed to the requesting library.

For public libraries, a typical request will be non-rush, will request a non-fiction printed item published in the latest 10 years, not a periodical or a government document. The Dewey classification is most likely to be 600 or 700. The request will come from the west side of the mountains, and go by mail to the State Library or a public library west of the mountains, usually to a library known to hold the item. It is likely to be filled at the first requested source, and the item sent by mail.

The finding that 58.9% of requests from academic libraries are filled by photocopies, as contrasted with 2.4% of requests from public libraries, fits with statistics given in a WILCO study (7), where 29.7 to 55.8% of academic libraries' requests were filled by photocopy and only 4.2 to 22.1% of public libraries' requests.

A typical request from a special library will be non-rush and will request a photocopied non-fiction periodical article, not from a government document, which has been published in the latest 10 years. The Dewey class is most likely to be the 600's, though again there are too few cases for reliability in this variable. The request will probably originate west of the mountains and go by mail to the State Library or a special library west of the mountains, or to PNBC. It will probably be filled at the first requested source and the item sent by mail.

Activity east and west of the Cascade Mountains is interesting. Libraries east of the mountains submit 26.3% of all requests, yet are the first requested source in only 6.6% of cases. The latter figure is skewed by the fact that both WSL and PNBC--the two switching centers--are on the west side of the state. Removing these cases from the calculation gives the first requested source as 16.3% on the east side and 83.7% on the west: still a discrepancy relative to origin of request, but a lesser one. It seems likely that libraries on the west side tend to use western libraries because of speedy access and collection size, and those on the east side request from western libraries because more large collections seem to be there, and the improved probability of success may increase speed. With increased access to holdings information via WLN, requests are apt to go to the nearest holding library and this situation will be alleviated. It should be noted that there are special local arrangments across state borders in two instances: Pullman, WA/Moscow, ID, and Vancouver, WA/Portland, OR. Requests in those patterns were not included in the study and therefore the sample probably underestimates activity in those areas.

The parameters revealing significant differences among type-of-library requests should be briefly commented on. All fiction requests in the sample came from public libraries. Academic libraries were heaviest originators of requests for periodicals with special libraries also strong and public libraries very light. The Washington respective figures for serials are compared in Figure A with Thomson's (76) 1966 figures and WILCO'S (72) 1976 data. Note that WILCO reports actual loans, not total requests; Thompson seems to include all requests. (As noted earlier, seldom can data from other studies be confidently compared.)

Public and special libraries originating requests were predominantly west of the mountains, but academics were more evenly divided. Public libraries were much more likely to send a request to a known location--probably because the WLN Resource Directory is the usual source for this information (except for serials lists), and academic and special librarians have not yet formed the habit of using it for interlibrary loan locations.

All three types sent more requests by mail than by any other mode but only academics used TWX and only public libraries used bookmobile. Each type tended to request first from WSL, and same-type libraries next--except for academics who used PNBC more frequently than they used other academic libraries.

Academic library requests are filled 91.9%, and specials 85.7% of the time, while public library patrons fare less well with 78.6% satisfied requests (see Table 12). However, when we eliminate from our sample the requests from the major public library borrower, the public library fill rate becomes a more compatible 83.0%. Of public libraries' un-

filled requests, poor citation was noted on 14%. Relating this fact to the reasons for all unfilled requests, we see that after not owned, poor citation is the most frequent culprit. Further, poor citation was most frequent in public library requests--and the heaviest borrower was responsible for 57% of those cases.

The fill rate for Washington of 83.1% overall, 91.9% for academic libraries, 78.6% for publics, and 85.7% for specials can be compared with NELINET's findings of 93.6% overall, and 96.5%, 86.6% and 79.9% respectively. NELINET reports a small sample for special libraries; in general, the New England fill rate seems markedly higher than Washington's. On the other hand, the report for Illinois (19) gives a 55.1% fill rate. The reasons for the differences might bear investigation.

The fill rates may also be compared with that of WILCO (7): academic libraries had a 73.8 to 84.3% fill rate, and public libraries 66.7 to 89.0%. The highest rate for public libraries (89%) was achieved by regional system libraries, whereas in our present study the district libraries filled a lower ratio of requests than did other public libraries.

The overall fill rate of 83.1% compares with 92.3% fill rate in 1977 in Illinois (29), and an 85.0% fill rate also in Illinois in 1977 found by Rouse (56).

A parameter related to fill rate is the number of requested sources. Figure B compares the average number of referrals by type of originating library with data from the WILCO study (72). While the differences among types of libraries is not statistically significant, it is worth commenting that special libraries in our sample did not refer any request beyond 3 sources; academics, not beyond 4. Apparently only the public libraries utilize as many as 5 referrals. In light of the King (24) estimate of $6.87 expenditure per lending library, this policy should be re-evaluated. The statewide average is 1.4 referrals, which matches a 1977 Illinois figure of 1.4 (Rouse, 61).

Illinois' reasons for nonfill match rather closely those for Washington (19):

	IL	WA
Not owned	69.1%	68.7%
Owned/not available	28.8%	23.8%
Other	2.1%	7.5%

While the statistics on publication date of requested items did not reveal significant differences among types of libraries, we can still make some comparisons with other studies--though here again, the time lapse reported is too often unique to a given study, or the sample of libraries is not sufficiently similar among studies. Material published more than 20 years earlier accounted for 16% of Washington's requests; NELINET (41) found in 1976-77 that 10% of items requested were more

than 20 years old. NELINET's sample was heavily weighted toward academic libraries, which does not match with Washington academic libraries' 24% of requests for the more-than-20-year-old materials. Thomson (76) reported in 1970 that 2/3 of academic libraries' requests, 1/3 of the books, 1/2 of the serials and government documents, and 2/3 of the technical reports, dissertations and masters' essays were published in the latest 20 years. West (83) reported in 1973 on a study of interlibrary lending in 8 California State University libraries; materials published in the latest 10 years were 48% of requests received (18% of requests did not originate in academic libraries); this compares with Washington academic libraries' 60% in the latest 10 years.

There have been relatively few studies of interlibrary loan in non-academic libraries. Strong (69), reporting on the Everett (Wa) Public Library, noted that only 51% of requests received were for items published in the latest 15 years; this reflects Everett's special strength in older fiction. Weech (82) provided data in 1968 for 4 Illinois Research and Reference Centers: 76% of items requested (from all types of libraries) were published during the latest 10 years--the figure for all Washington libraries is 72.6%, a near match.

Washington's requests for periodicals amounted to 23.3% of all requests; Weech found that periodicals were 12.2% of requests. It is possible that the Illinois sample contained a higher proportion of public library requests than did the Washington sample.

TABLE 9

LIBRARIES ORIGINATING REQUESTS

Originating Library	Portion of Sample Requests
Timberland Regional Library (26 libraries)	24.2% *
North Central Regional Library (25 libraries)	6.6
King County Library System (40 libraries)	6.3
The Evergreen State College	4.0
Pierce County Library (17 libraries)	3.3
Boeing Company (Kent)	3.3
Eastern Washington University	2.6
Western Washington University	2.3
Kitsap Regional Library (9 libraries)	2.3
Fort Vancouver Regional Library (8 libraries)	2.3
Battelle (Seattle)	2.3
Boeing Company (Renton)	2.3
Whitworth College	1.7
Port Townsend Public Library	1.7
North Olympic Library System (4 libraries)	1.7
Spokane County Rural Library District (8 libraries)	1.7
Cascadia Reception-Diagnostic Center	1.7
U. S. Veteran's Administration Hospital (Tacoma)	1.7

47 other libraries requested less than 1.5% each.

Type of Originating Library	No. of Libs.	% of Libs.	No. of Requests	% of Requests
Academic				
Colleges and Universities	11	16.9%	48	16.1%
Community Colleges	9	13.8	14	4.7
Public	19	29.2	172	57.5
Special	26	40.0	65	21.7
	65	99.9%	299	100.0%

* At the time of data collection, Timberland evidently had a policy that whenever a librarian could not satisfy a patron's request, an interlibrary request was automatically generated. Statistical methods have been used to eliminate possible bias in findings.

TABLE 10

DATA ON REQUEST PARAMETERS

Parameter	Number of Cases	% of Total Requests	
Rush	1120	2.5%	
Publication Date	245		
1968-77		72.2%	
1958-67		11.8	
1948-57)		4.5)	
1938-47)		1.2)	
1928-37) n = 39		2.4)	16.0%
1918-27)		3.7)	
1908-17)		2.0)	
Before 1908)		2.0)	
Fiction	202	5.9%	
Classification	132		
000		5.3%	
100		4.5	
200		3.0	
300		15.9	
400		-	
500		8.3	
600		28.0	
700		19.7	
800		3.8	
900		11.4	
Periodical	258	23.3%	
Government Document	1085	4.9%	
Medium	1121		
Print		94.8%	
Microform		5.1	
Audio Recording		0.1	
Requesting Library Location	302		
East of Mountains		26.5%	
West of Mountains		73.5	

TABLE 10 (cont.)

DATA ON REQUEST PARAMETERS

Parameter	Number of Cases	% of Total Requests
Requesting Library Type	302	
Academic		20.5%
Public		57.6
Special		20.9
WSL		1.0
Known Location	304	41.1
Mode of Transmission of Request	206 1/	
Mail		59.7%
Telephone		6.8
TWX		3.4
Search Lending Library		13.6
Courier		15.5
Bookmobile		1.0
First Requested Source Location	296	
East of Mountains		6.6%
West of Mountains		93.4
First Requested Source	296	
Academic		7.8%
Public		22.6
Special		9.5
WSL		49.0
PNBC		10.5
Out of State		0.7
Number of Requested Sources	296	
1		71.3%
2		15.7
3		9.7
4		2.3
5		1.0
Filled	301	83.1%
Material Sent	233	
Original		70.4%
Photocopy		29.6

1/ Excluding requests from one district library submitting more than 25% of total requests

TABLE 10 (cont.)

DATA ON REQUEST PARAMETERS

Parameter	Number of Cases	% of Total Requests
Mode of Transportation of Material	242	
Mail		82.2%
Courier		17.8
Reason Unfilled	49	
Not owned		68.7%
In circulation		14.9
Missing		3.7
Patron cancelled		1.5
Too new		2.2
Poor citation		3.7
Does not circulate		5.2

TABLE 11

COMPARISON OF REQUESTS ORIGINATING IN ACADEMIC, PUBLIC, AND SPECIAL LIBRARIES

Parameter	Academic		Public		Special	
	No. of Cases	%	No. of Cases	%	No. of Cases	%
Rush	46	1.6%	170	2.9%	50	1.6%
Publication Date	38		159		48	
1968-77		60.5%		71.7%		83.3%
1958-67		15.8		10.1		14.6
1948-57		5.3		5.0		2.1
1938-47		-		1.9		-
1928-37		5.3		2.5		-
1918-27		5.3		4.4		-
1908-17		2.6		2.5		-
Before 1908		5.3		1.9		-
Fiction*	39	-	120	10.0%	43	-
Classification	17 *		98		17 *	
000		5.9%		6.1%		-
100		5.9		5.1		-
200		5.9		2.0		5.9%
300		11.8		15.3		23.5
400		-		-		-
500		5.9		7.1		17.6
600		35.3		23.5		47.1
700		11.8		24.5		-
800		5.9		4.1		-
900		11.8		12.2		5.9
Periodical*	43	60.5%	167	5.4%	48	52.1%
Government Document	44	4.5%	168	4.8%	48	4.2%
Medium	44		167		50	
Print		95.5%		95.2%		96.0%
Microform		2.3		4.8		4.0
Audio Recording		2.3		-		-
Requesting Library Location*	62		174		63	
East of Mountains		41.9%		21.3%		27.0%
West of Mountains		58.1		78.7		73.0
Known Location*	62	1.6%	174	54.0%	63	15.9%

TABLE 11 (cont.)

COMPARISON OF REQUESTS ORIGINATING IN ACADEMIC, PUBLIC, AND SPECIAL LIBRARIES

Parameter	Academic		Public		Special	
	No. of Cases	%	No. of Cases	%	No. of Cases	%
Mode of Transmission of Request*	55		154 ‡‡		55	
Mail		47.3%		64.1%		63.6%
Telephone		7.3		7.6		5.5
TWX		12.3		-		-
Search lending lib.		18.2		14.1		9.1
Courier		14.5		12.0		21.8
Bookmobile		-		2.2		-
First Requested Source Location	62		174		63	
East of Mountains		8.1%		8.6%		-
West of Mountains		91.9		91.4		100.0
First Requested Source*	56		174		61	
Academic		23.2%		2.3%		8.2%
Public		3.6		33.9		9.8
Special		10.7		3.4		23.0
WSL		35.7		58.0		39.3
PNBC		25.0		2.3		18.0
Out of State		1.8		-		1.6
Number of Requested Sources	59		174		62	
1		69.5%		78.7%		79.0%
2		20.3		12.1		17.7
3		6.8		12.6		3.2
4		3.4		2.9		-
5		-		1.7		-
Filled*	62	91.9%	173	78.6%	63	85.7%
			100 ‡‡	83.0		
Material Sent	56		126		48	
Original		41.1%		97.6%		33.3%
Photocopy		58.9		2.4		66.7
Mode of Transportation of Material	55		132		51	
Mail		74.5%		93.2%		62.7%
Courier		25.5		6.8		37.3

TABLE 11 (cont.)

COMPARISON OF REQUESTS ORIGINATING IN
ACADEMIC, PUBLIC, AND SPECIAL LIBRARIES

Parameter	Academic		Public		Special	
	No. of Cases	%	No. of Cases	%	No. of Cases	%
Reason Unfilled	4 ♦		35		10 ♦	
Not owned		50.0%		63.7%		60.0%
In circulation		-		5.7		10.0
Missing		-		2.9		10.0
Patron cancelled		-		5.7		-
Too new		-		5.7		10.0
Poor citation		25.0		14.3		10.0
Does not circulate		25.0		-		-

* Differences statistically significant in a chi-square test at better than .05.

♦ Probably not a meaningful distribution: too few cases.

♦♦ Minus requests from the district library submitting more than 40% of public library requests.

FIGURE A

PERIODICALS AS PERCENT OF TOTAL REQUESTS
BY TYPE OF LIBRARY
Comparison of Three Studies

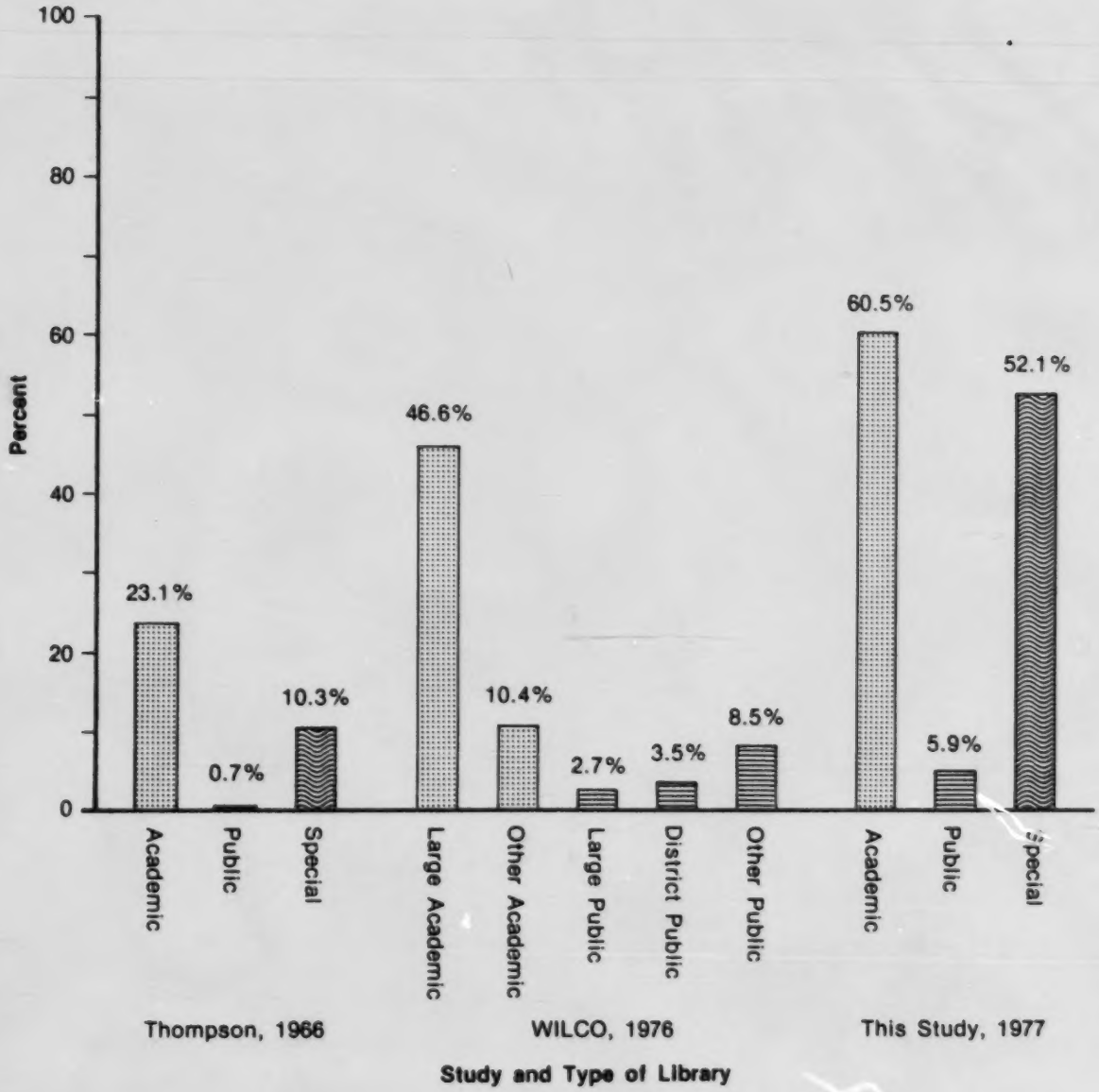
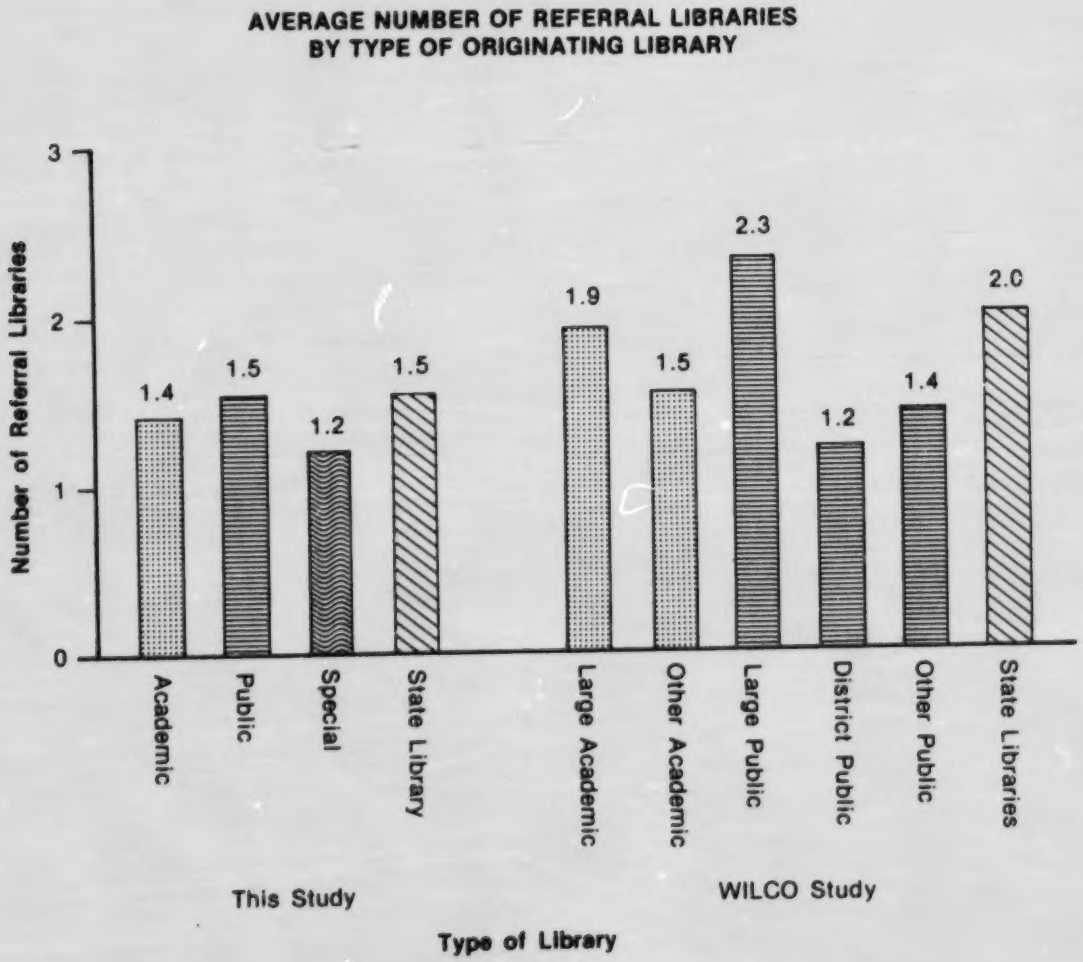


TABLE 12

FILL RATES BY TYPE OF
ORIGINATING LIBRARY

	Total Requests Originated	Items Received	% of Fills
Academic	62	57	91.9%
Public	173	136	78.6
Special	63	54	85.7
WSL	3	3	100.0
Unknown	3	--	
	304	250	83.1%

FIGURE B


AVERAGE NUMBER OF REFERRAL LIBRARIES
BY TYPE OF ORIGINATING LIBRARY
Number of Referral Libraries
3
2
1
0
1.4
1.5
1.2
1.5
1.9
1.5
2.3
1.2
1.4
2.0
Academic
Public
Special
State Library
Large Academic
Other Academic
Large Public
District Public
Other Public
State Libraries
This Study
WILCO Study
Type of Library

42

Lending Patterns

A total of 37 Washington libraries, and PNBC, received the 304 requests in the sample as first, second, third, fourth or fifth referral. The ratios of receipts are listed in Table 13. (Each district library is counted as one referral, though the requested item may be referred to several, or supplied from any, member library).

A total of 32 libraries were actual lenders of material (253 items) in our sample. The libraries supplying more than 1.2% of the items are listed in Table 14, with percent of total provided.

The 1970 Washington study (81), based on data reported by libraries, found that loans in the state were made by 8 libraries (excluding special libraries):

Washington State Library	63%
Seattle Public	13
University of Washington	10
Everett Public	4
Tacoma Public	4
Spokane Public	2
Washington State University	2
Timberland Regional	2
	100%

Relative positions and ratios have changed markedly in 7 years; perhaps the greatest single factor in this change is WLN's computerized bibliographic data base. Six of the libraries named in Table 14 but not on the 1970 list are WLN participants. The re-alignment might trigger a re-evaluation of state subsidies for interlibrary lending, as three of the four subsidized libraries are not among the major lenders.

Table 15 shows the ratios of referral for each type of library; within the three types of academic, public and special, it is true as other studies (e.g., NELINET) have found, that like tends to request from like. If we eliminate WSL, PNBC, and out-of-state libraries from conideration, the pattern shows more clearly (Table 16). Table 17 compares our findings with those of other studies.

That lending/borrowing by type is somewhat level is demonstrated in Table 18. Academic libraries, for example, furnish 20.7% of requests in the state and receive 26.1% of referrals, while public libraries receive a slightly lower ratio of referrals than they furnish in requests and special libraries services seem about even. (This, of course, does not indicate the level of lending/borrowing so far as individual libraries are concerned.) Washington academic libraries in 1977 lent 1.05 items for each item borrowed; Palmour (52) found that academic libraries nationally averaged 1.7 items lent to 1 item borrowed. WSL lends 32% of the in-state load and borrows less than 1%; UW lends 13.3% and borrows 4.5% instate. (UW's reported figures, including out-of-state commerce, show 5.75 items lent for each item borrowed.) Other

major libraries reporting more than a 1.5 ratio of lending to borrowing are Washington State University, Everett, Seattle, Spokane, and Tacoma public libraries, and Gonzaga University. Table 19 shows lending/borrowing ratios by type of library; this data is based on a telephone survey, not the sample of 304 cases.

The number of libraries referred to is shown in Table 20. Since only an additional 2.8% of requests are filled in the fourth and fifth referrals, and costs of interlibrary loan mount sizeably with each referral (estimated at $6.33), a possible protocol might limit referrals to three, except in extraordinary cases. That this ratio holds for at least one other library is demonstrated in Figure C.

Fill rates for the types of referral libraries are shown in Table 21. The fill rate by WSL seems low, but is explained by WSL's function as a switching center for public libraries' requests.

Fill rates for each type of originating library were given in Table 12. It should be remembered that loans between member libraries of a district library system were not considered interlibrary loans for purposes of this study. The transactions recorded here are all outside a system, whether it be a municipal library with branches, a university with a number of departmental libraries or a public library headquarters with many local library members.

Table 22 shows responses of requested libraries. In this tabulation, an item could have been unfilled by one or more libraries, and the PNBC referrals are tallied again in other columns for subsequent referred libraries.

TABLE 13

REQUESTED LIBRARIES

Library	Portion of Receipts
State Library	34.8%
PNBC	18.1
Seattle Public Library	5.2
Pacific NW Regional Health Services Library	5.2
University of Washington Library	4.5
Sno-Isle Regional Library	2.8
Spokane County Library	2.4
Kitsap Regional Library	1.9
Evergreen State College Library	1.6
Tacoma Public Library	1.6
Timberland Regional Library	1.6
North Central Regional Library	1.4
Spokane Public Library	1.4
Pierce County Library	1.4
Federal Archives and Records Center	1.4
Fort Vancouver Regional	1.2

The other 22 libraries each received less than 1% of the referrals. Out-of-state libraries received 4.5% of referrals.

TABLE 14

LENDING LIBRARIES

State Library	32.0%
University of Washington	13.3
(46.9% of these by PNBC using U of W materials)	
Pacific NW Regional Health Sciences Library	6.8
Sno-Isle Regional Library	5.0
Evergreen State College Library	2.9
Spokane County Library	2.9
Kitsap Regional Library	2.5
North Central Regional Library	2.5
Pierce County Library	2.5
Seattle Public Library	2.5
Timberland Regional	2.5
Federal Archives and Records Center	2.5
Spokane Public Library	2.1

The other 19 lending libraries each supplied 1.2% or less. Out-of-state libraries filled 5.4% of all the filled requests.

TABLE 15

REFERRALS BY TYPE OF LIBRARY[1]

Referred Library	Academic	Public	Special
Academic	28.9%	6.8%	9.2%
Public	6.0	32.1	10.5
Special	12.0	2.6	22.4
WSL	25.3	39.2	31.6
PNBC	24.1	14.7	21.0
Out of State	3.6	4.5	5.3
	99.9%	99.9%	100.0%

[1] Includes referrals as first, second, third, etc. library.

TABLE 16

REFERRALS BY TYPE OF LIBRARY
(excluding referrals to WSL,
PNBC and Out of State)

Type of Originating Library

Referrals To	Academic	Public	Special
Academic	61.5%	16.4%	21.9%
Public	12.8	77.3	25.0
Special	25.6	6.4	53.1
	99.9%	100.1%	100.0%

TABLE 17

BORROWINGS FROM SAME TYPE LIBRARIES
COMPARISON OF STUDIES

Type Borrower	Same Type Lender				
	WA	Palmour	NELINET	WILCO	Strong
Academic	61.5%	60%	87%	70%+	-
Public	77.3%	-	63%	80%+	88.9%

TABLE 18

Type Library	# Requests Originated	% of Total Originated	# Requests Received	% of Total Received
Academic	62	20.7%	47	26.1%
Public	174	58.2	97	53.9
Special	63	21.1	36	20.0
	299	100.0%	180*	100.0%

*This total is less than total referrals since it excludes referrals to WSL and to PNBC.

TABLE 19

LENDING/BORROWING RATIOS*

Type Library	Average Annual Lending	Average Annual Borrowing	Ratio
Community Colleges	92	264	.4
Public Colleges and Universities	3,147	3,052	1.4
Private Colleges and Universities	204	493	.7
Independent Public	105	429	.3
District Libraries	2,019	5,624	.6
WSL	42,000	2,700	15.6

*Data for special libraries not available.

TABLE 20

NUMBER OF REFERRAL LIBRARIES: FILL RATE

Number of Referral Libraries	Total Requests	Number of Requests Stopping Here	Fills	% of Total Fills
1 Library	304	214	175	70.0%
2 Libraries	86	47	37	14.8
3 Libraries	39	29	27	10.8
4 Libraries	10	7	5	2.0
5 Libraries	3	3	2	0.8
Unknown	4	4	4	1.6
		304	250	100.0%

FIGURE C

PERCENT OF ACADEMIC LIBRARY REQUESTS FILLED AT EACH REFERRAL LIBRARY COMPARED WITH OTHER STUDIES

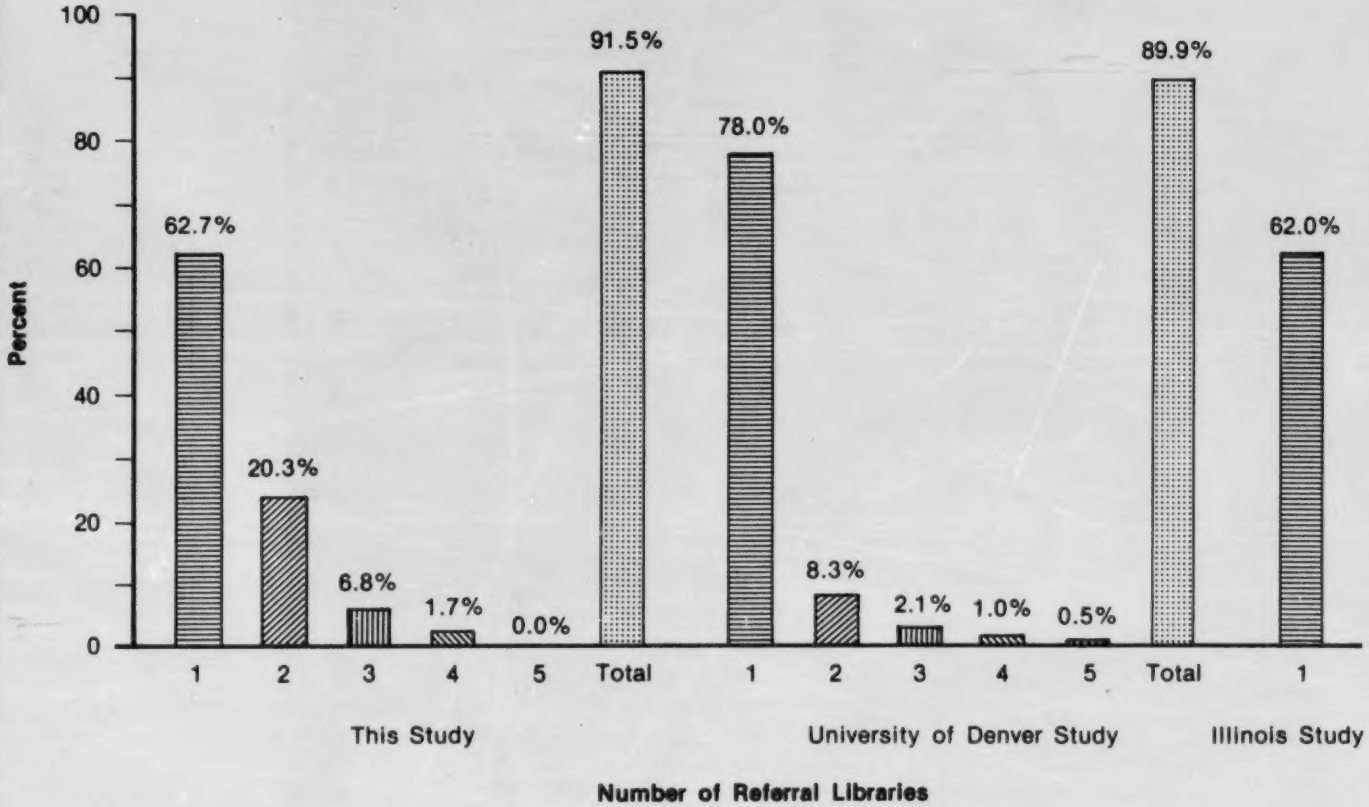


TABLE 21

REQUESTS RECEIVED AND FILLED BY
TYPE OF REFERRAL LIBRARY

Type of Library	Requests Received	% of Total Requests	Items Lent	% of Total Items Lent	% of Fills
Academic	49	10.7%	55*	20.1%	91.9%
Public	100	21.8	66	24.1	66.0%
Special	36	7.9	30	11.0	83.3%
WSL	149	32.5	101	36.9	67.8%
PNBC	79	17.2	--	--	--
Out-of-State	20	4.4	14	5.1	70.0%
Not Reported	25	5.5	8	2.9	____
TOTAL	458**	100.0%	274	100.0%	

* Includes PNBC lending from University of Washington collection.
**304 requests, more than 1 library for 90 requests; 214 stopped at one library.

TABLE 22

RESPONSES OF REQUESTED LIBRARIES

Type of Library	Item Sent	Reserved	Unfilled	Referral (PNBC only)
Academic	36	0	11	--
Public	61	8	28	--
Special	30	0	6	--
WSL	63	15	69	--
PNBC	17	0	16	46
Out-of-state	11	0	6	--

Transaction Times

The average transaction absorbs 26 days between patron request and patron receipt of material or notification of nonavailability. Of this, an average of 14 days are spent in processing in the patron's own library before sending out the request, and 4 days in each referral library.

Table 23 shows the allocation of time among steps of a typical transaction. The mean time for transmittal of requests was 3.2 days, or 12.6% of total transaction time, with a range from 0 to 20 days. Original library processing absorbed an average of 53% and requested sources (1.4 referrals) 23.7%, of total time; in other words, 76.7% of the time is spent in internal processing.

When we consider an ideal transaction time, we see that 10% of the requests are completed within 6 days. This is not an impossible goal; the 10% and 50% timings are shown in Table 24.

In the NELINET study (41), overall transaction time averaged 10.5 days, less than half the Washington average. At the University of Denver, the average is reported as 23 days (45). Other studies report 16 to 18 days on average (68).

A clue to one source of Washington's slow transaction throughput can be seen in Table 25. The marked difference between the means of public libraries' transaction time and that of other types is apparently due to two main factors: the public libraries tended to send requests to more libraries before giving up than did academic or special libraries (see Tables 26 and 27); also, the headquarters libraries consumed time in searching their own member libraries before entering on the interlibrary loan operation and this internal time absorbs 1/3 of the total transaction time for public libraries (Table 28). It should be noted that while Washington academic libraries averaged 1.4 days' processing in-house, the University of Denver is reported as averaging 3.3 days (45). Figure D compares data collected from 100 western libraries by the Western Interstate Library Coordinating Organization (72).

One of the extreme long-hanging requests at a district library bears mentioning. A January 1975 request for the Nancy Drew Cookbook had been requested once a year ever since, still with no success. The would-be cook has probably forgotten that it was ever requested and has almost certainly graduated to Fanny Farmer or Julia Childs. This sort of perseveration on the librarians' part seems more stubborness than professional diligence.

Table 29 gives average referral response times for the total sample and by type of requested library. Washington's overall mean response time was 5.6 days with 24% responses within 1 day and 60% within 3 days.

The NELINET study (77) found response time for each lending library to average 2.5 days, with 32% responding in less than 1 day and 85% within 3 days.

Washington response rates for academic libraries were 17% within 4 days and 87% within 9 days; West (83) in a study of eight California State University libraries found that 28% of responses were completed within 4 days and 63% within 9 days.

NELINET found that amount of lending did not correlate with speed of response; the same conclusion must be drawn in Washington. Some of the most frequent lenders are among the slowest responders and some are among the fastest. Libraries receiving perhaps one request a month seem often to give special attention and speed it through their operations.

An analysis of the time absorbed by various responses is shown in Table 30. The 'reserved' response is simply setting a name in a waiting queue and notifying the requester; it does not include waiting time until the item is actually in hand.

The awareness of a known location might be expected to make a difference in response time, especially for the first library requested--see Table 31. Total transaction time unexpectedly shows a reverse correlation. This is perhaps due to the fact that owning libraries sometimes place a reserve on an item in circulation, and the request may then sit overlong without further referral.

Rush requests do operate as would be expected, as shown in Table 32.

Dougherty and Blomquist (14) assert that while citations and locations are essential for efficient interlibrary loan transactions, prompt delivery of materials is also vital. In our sample, delivery of requested materials from lending to borrowing library absorbs an average of 2.9 days (Table 33), or 11.4% of total transaction time. Courier delivery averages 1.2 days as compared with 3.2 days for mail delivery. Mail traveling across the Cascade Mountains (Table 34) requires 3.9 days as compared with 2.9 days on the same side of the mountains. This difference of one day for cross-mountain delivery was also found by the investigators in a 1974 study (54).

Obviously as percent of total transaction time, neither transmission of request nor delivery of materials are bottlenecks--the problem as we have seen, is internal processing time, in both the originating and the responding libraries. If this area were improved, patrons would see an appreciable effect on service. This finding is stated also in a 1971 Washington State Library study (81): "Most interviewees expressed doubts as to the necessity of instantaneous transmission of documents or information. Rather, they expressed that 3 to 7 days response time would be satisfactory and thought that internal improvement of interlibrary loan operation at the bigger libraries would do more to promote adequate service than formalizing the existing infor-

mal structure and increasing the bureaucratic aspects associated with the formalization."

The technology of telefacsimile transmission has not been developed significantly since the 1967 pilot test at the New York State Library (39); it is still not possible to transmit directly from a bound volume, but a single-page photocopy must first be produced for passing around the facsimile machine's drum. Until this problem is overcome, it is unlikely that telefacsimile can be a major tool of libraries.[6]

The landmark New York study found that each request utilizing telefacsimile cost about $62, with poor quality of received copy due to the above-described problem. Seventy percent of recipients said that the material could have been equally useful if it had been received 2 to 3 days later, therefore timeliness was not worth the expense. It was found that other stages of interlibrary loan procedures were slower than mail delivery; e.g., internal searching and handling of request in referral libraries. Poor copy and insufficient demand were the major reasons for stopping the service.

A 1973 study in the California State Unversity and Colleges (83) analyzed the value of telefacsimile in interlibrary transactions, finding that 67% of loans via telefacsimile were filled within 9 days, while 64% were filled in the traditional mode within 9 days. For 4 days' time, 19.5% were filled via telefacsimile and 15% via the traditional mode. "...Another aspect of the study was an analysis of the ILL transactions themselves: type of material involved, user types and transaction times. Of the 3,490 transactions analyzed, the mean labor cost per transaction was $4.73; $5.94 when telefacsimile transmission was used. There was no significant difference in transaction time between traditional and telefacsimile transmission methods...It does not appear that use of the telefacsimile equipment can be justified for ILL request transmittal alone."

---

[6] As this report was in production, a rumor purported that one manufacturer has solved this problem.

TABLE 23

ELEMENTS OF TRANSACTION TIME [1/]
(in days)

Transaction Time	No. Cases	Mean	Standard Deviation	Range
Original library processing	34	13.7 days	27.8	0-161
Transmittal of request	56	3.2	4.4	0-20
Requested source processing	174	4.4	7.3	0-46
Delivery of material	154	2.9	2.2	0-9
Total time	275	25.5 days	26.6	0-203

1/ Total time includes referral to more than one library; each segment in the upper part of the table is based on one library or interlibrary operation.

TABLE 24

TRANSACTION TIMES, SPEEDIER REQUESTS

	Cases	50% Within No. of Days	10% Within No. of Days
Total time	255	17	6
Original library processing	34	5	2
Transmittal of request	56	2	0
Requested source processing	174	2	0
Delivery of material	154	3	0

TABLE 25

MEAN TIME FROM PATRON REQUEST TO RECEIPT OF ITEM OR FINAL REFUSAL

Type of Originating Library	No. of Cases	Mean No. of days	Range
Academic	57	14.4 days	0-66
Public	157	34.7 days	3-203
Special	58	11.4 days	2-38
WSL	49	34.3 days	2-221

TABLE 26

NUMBER OF REFERRAL LIBRARIES
BY TYPE OF ORIGINATING LIBRARY

Originating Library	No. of Referral Libraries					Mean Number
	1	2	3	4	5	
Academic	42	12	4	2	0	1.4
Public	123	21	22	5	3	1.5
Special	49	11	2	0	0	1.2
WSL	24	24	1	0	0	1.5

TABLE 27

TIME TO CONCLUSION
BY NUMBER OF REFERRAL LIBRARIES

Number of Referred Libraries	Mean Days to Conclusion	Range	Number of Cases
1	21.2 days	0-203	196
2	33.4 days	9-95	43
3-5*	37.2 days	8-84	31

*Too few cases to analyze each number of libraries separately.

TABLE 28

TOTAL TRANSACTION TIME
ABSORBED BY ORIGINATING LIBRARY

Type of Originating Library	Mean Delay	Range	Mean Total Time	Range	% Delay In-House
Academic	1.4 days	0-24	14.4 days	0-56	9.7%
Public	11.7	1-159	34.7	3-174	33.7%
Special	0.9	0-15	11.4	2-38	7.9%
WSL	2.5	0-17	34.3	2-221	7.3%
All libraries	7.1	0-159	25.5	0-221	27.8%

TABLE 29

MEAN RESPONSE TIME FOR
TYPE OF REFERRAL LIBRARY

Type of Referral Library	Number of Cases	Mean No. of Days Response	Best 50%	Best 10%	Range
Academic	199	4.3	2	0	0-76
Public	217	5.3	1	0	0-124
Special	27	6.3	5	1	1-24
WSL	194	4.4	2	0	0-57
PNBC	447	6.3	3	1	0-151
All responses	748	5.6			0-151

FIGURE D

AVERAGE TOTAL DAYS PER TRANSACTION BY TYPE OF ORIGINATING LIBRARY, COMPARED WITH FINDINGS OF WILCO STUDY

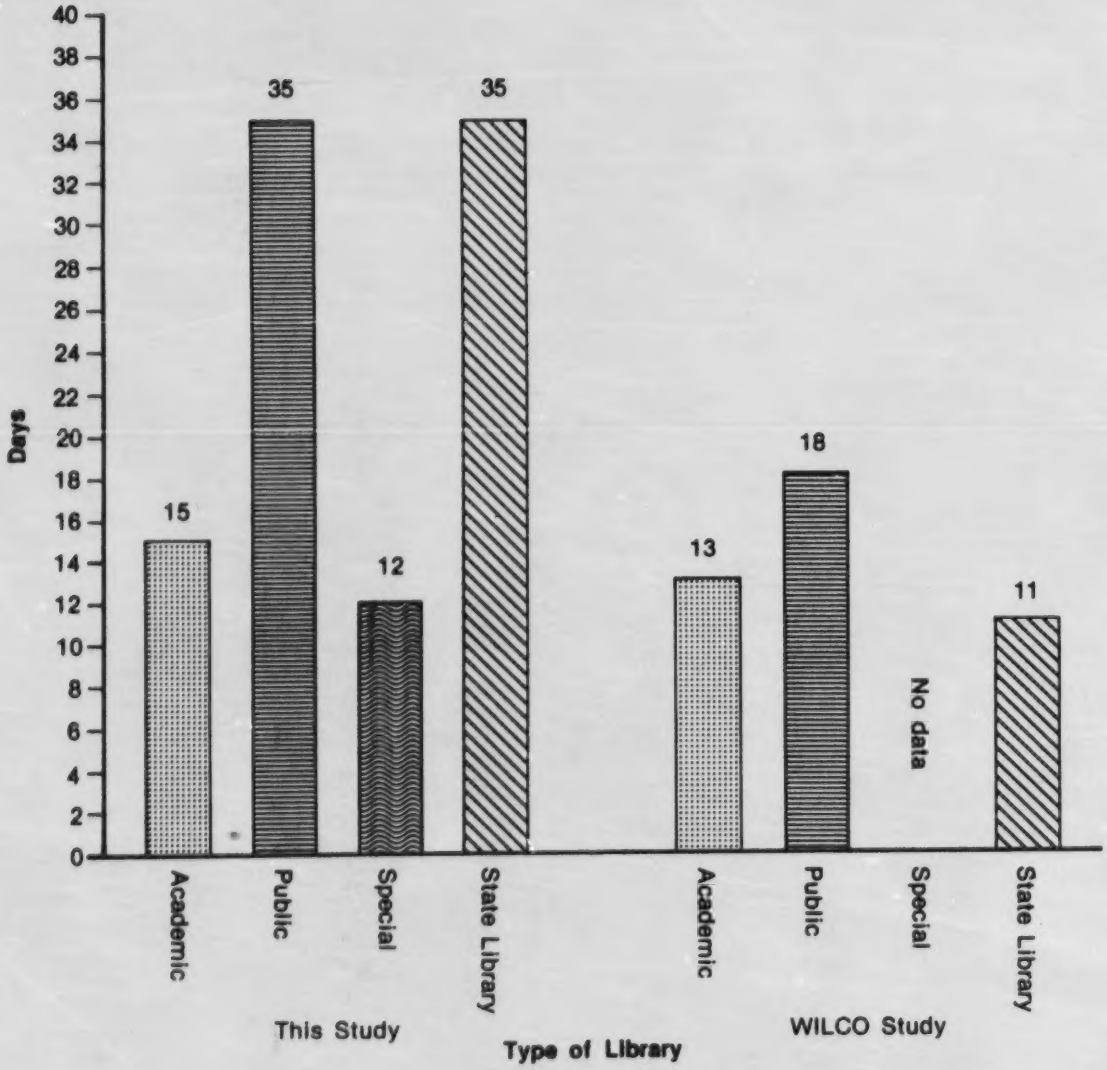


TABLE 30

RESPONSE TIME FOR RESPONSE TYPES

Type of Response	Mean Response Time
Unfilled	2.26 days
Filled	3.01
Reserved	3.46
PNBC Referral	6.15

TABLE 31

RESPONSE TIME AS RELATED
TO KNOWN/UNKNOWN LOCATION OF ITEM

		Lib 1 Response Time	Total Transaction Time
Known Location	Mean	1.8 days	35.7 days
	Range	0-9	3-203
Unknown Location	Mean	2.4 days	20.2 days
	Range	0-10	0-84

TABLE 32

MEAN TIME AS RELATED TO
RUSH/NON-RUSH REQUESTS

	Lib 1 Response	Total Transaction Time
Rush Requests	1.5 days	11.3 days
Non-Rush Requests	4.9 days	25.1 days

TABLE 33

TIME FOR DELIVERY OF MATERIALS

Mode of Delivery	Mean No. of Days	Range
Mail	3.2 days	0-8
Courier	1.2 days	0-9
All cases	2.896	0-9

TABLE 34

MAIL DELIVERY TIME ACROSS
MOUNTAINS AND SAME SIDE

	Mean No. Days	Range
Across Mountains	3.9	0-8
Same Side	2.9	0-9
All Cases	3.3	0-9

Filled/Unfilled Requests

To investigate the relationships between parameters of a request and the probability of its being filled, a number of chi-square tests were run. Parameters which demonstrated values significantly different (better than .05) between filled and unfilled requests are given in Figure E. It seems probable that the first parameter is measuring the known location parameter, since requests for periodicals are frequently routed on the basis of union serials lists.

The relationship between type of requesting library and fill rate is somewhat puzzling until we drop out of the public library data the one district library which originates more than 1/3 of the requests. The fill rate for public libraries then rises to 83.0% and the difference is no longer significant.

The one strong relationship between any variable and the fill rate is, then, found with known/unknown location. When a request is sent to a known location it has a 97.6% probability of being filled, against only 72.4% for requests sent without ascertaining an owning library.

Table 35 shows the impressive fill rate of known vs. unknown locations on requests going to only one requested source; the logic of this analytic step is that the known location characteristic applies to the first requested library but not necessarily to further referrals.

A further investigation is shown in Table 36; requests for known-location items tend to be completed with fewer referrals than those for items with no known holding library.

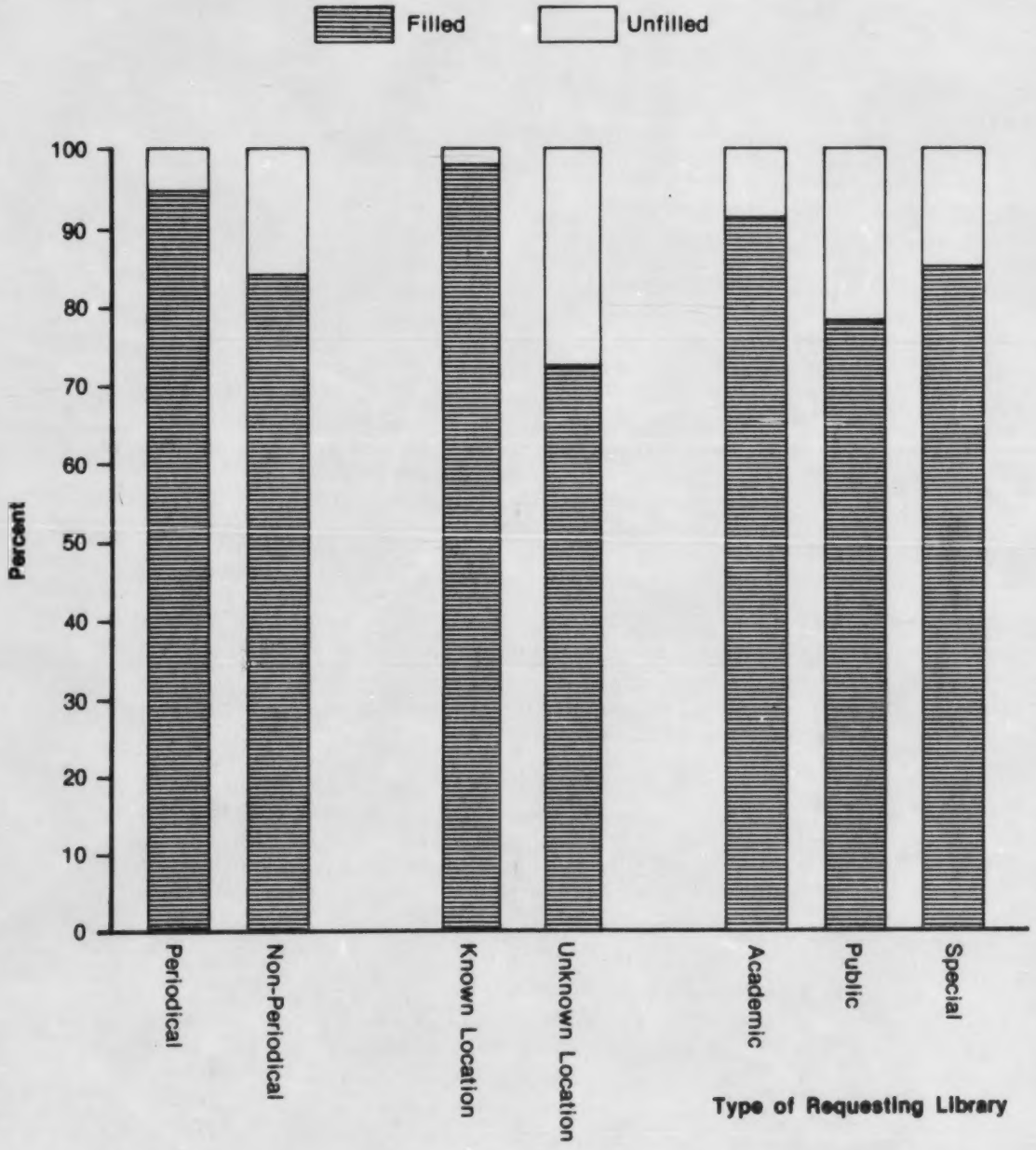
In a situation where ownership of the item is known, the first requested library responds in an average of 1.8 days; when ownership is unknown, this response averages 2.4 days. These become, in actuality, 2 and 3 days, since transport is usually available once a day.

Of the requests not sent to a known holding library, 62.9% of unfilled requests were for items not owned, while none of those sent to a known holder were unfilled for that reason. An obvious conclusion from this analysis is that sending a request to a library which is known to own the needed item can greatly improve probability of success and speed of response, with a concomitant reduction in cost by limiting the number of referrals.

Utilization of known location information by each type of originating library was given in Table 11: academic libraries, 1.6% of requests sent to a known location; public libraries, 54.0% and special libraries, 15.9%. The differences are probably due to the fact that most members of WLN during the first few years have been public libraries, and college and special libraries have not yet formed the habit of referring to the WLN Resource Directory.

FIGURE E

COMPARISON OF FILL RATE FOR SELECTED PARAMETERS*



*Differences statistically significant in a chi-square test at better than .05.

TABLE 35

FILL RATE FOR REQUESTS STOPPING
AT FIRST REFERRAL LIBRARY*

	Unfilled	Filled
Unknown Location	34.9%	65.1%
Known Location	0.9%	99.1%

* Difference significant at better than .00005.

TABLE 36

NUMBER OF LIBRARIES IN REQUEST
SEQUENCE FOR KNOWN/UNKNOWN LOCATION REQUESTS *

	Number of Requested Libraries				
	1	2	3	4	5
Known Location	85.6%	8.0%	14.3%	3.4%	0
Unknown Location	61.1%	21.1%	13.8%	0.8%	2.4%

* Difference significant at better than .00005

ROLE OF THE WASHINGTON STATE LIBRARY

The State Library serves both as a major lending library and as a switching center for interlibrary loan. Most public libraries and community college libraries transmit requests first to WSL, though this pattern is shifting to requesting directly as more locations of materials become accessible through WLN. Still, when the State Library is known to hold an item, or when no location is known, WSL is usually the public libraries' first point of access. Table 37 shows sources of requests received at WSL in the study sample.

In our sample, 48% of all requests in the state were sent first to WSL and another 1% as second or third referral. Of these, 67.8% were filled at WSL and 32.2% were referred. Of the 32.2%, 70.2% were sent to PNBC for further routing. The fill rate of WSL compares favorably with rates for other state libraries in past studies, as shown in Table 38. This is a loose comparison, as rates will have changed in the intervening years, and there is no assurance that the services and types of requests are actually comparable.

Analysis of the 149 requests received at WSL as first, second or third referral shows (Table 39) that 70.0% were published in the latest 10 years and 90.0% in the latest 20 years. A third of the requests are for material classified in the Dewey 600's. Periodicals constitute 13.2% of requests; government documents, 1.5%; 20.2% of filled requests received photocopies. While 67.8% of requests were filled by WSL, an additional 11.3% were filled by subsequent libraries for a final fill rate of 79.1%.

Response time for WSL is shown in Figure F and Table 40; this is based on 187 requests received by WSL, drawn from the 1496case sample which includes the random sample plus all of several libraries' requests. It is assumed that WSL response time would not be affected by the source of the request. Only 187 of the 552 requests received by WSL had data for all parameters necessary for this calculation.

Table 41 compares 1969 and 1977 requests received at WSL. Demand has apparently shifted toward more recent materials--whether as a result of demand itself or of WSL's acquisitions policy is not known. The subject matter of requests has shifted away from the 100's, 400's, and 900's toward the 600's and 700's--again, whether because of interest or availability is uncertain.

If a request is not filled by WSL, the item may be either not owned, missing or in circulation. If it is in circulation, a reserve is placed on the item unless there are already more than 6 requests in queue, in which case the request is sent on to another library.

Sometimes an order is initiated from a request, or a requested item may be already on order. If the item is on order or being ordered, a

notice is sent to the requesting library. If the item is missing, it is searched for a week and then a notice is sent. If the request is forwarded to another library, the requesting library is notified except when the referral is within WLN. Rationale for this latter rule is that there are not enough copies of the multiple request form to trace all referrals in the network; it would seem, however, that at least the forms available should be used--and as WSL is usually the first requested library if it is requested at all, the form is there to be used and would help keep the requesting library informed of status.

TABLE 37

ORIGINATING LIBRARIES FOR REQUESTS
RECEIVED FIRST AT WASHINGTON STATE LIBRARY*

Library	% of Requests
Timberland Regional Library	30.1%
North Central Regional Library	9.6
Evergreen State College	6.2
Kitsap Regional Library	4.1
Port Townsend Public Library	3.4
North Olympic Library System	3.4
Fort Vancouver Regional Library	3.4
Lower Columbia Community College	2.7
Pierce County Library	2.7
Cascadia Reception-Diagnostic Center	2.7
Washington State Penitentiary	2.7
Whitman County	2.0
Rainier School (State Institution)	2.0
Anacortes Public Library	1.4
Kelso Public Library	1.4
Spokane County Library	1.4
Mid-Columbia Referral Library	1.4
Purdy Treatment Center for Women	1.4

24 other libraries, each less than 1%: community colleges, private colleges, public libraries, state and federal agencies, state institutions, medical libraries, and business and industry.

*146 requests received by WSL as first requested library, from sample of 304 requests generated in state.

TABLE 38

State Library	Year of Study	Percent Filled
Pennsylvania	1967	43.1%
California	1965	48.2%
New York	1964	60.0%
Illinois	1972	56.5%
Washington	1977	67.8%

TABLE 39

ANALYSIS OF REQUESTS RECEIVED
AT WSL
(n = 149)

Characteristics	%
Rush	4.1
Publication date	
Latest 10 years	70.0
More than 20 years	20.0
Average	19.3 years
Classification	
000	5.2
100	5.2
200	2.6
300	15.6
400	--
500	2.6
600	32.5
700	22.1
800	5.2
900	9.1
Periodicals	13.2
Government Documents	1.5
Material From	
Print	98.5
Microform	1.5
Transmission of Requests	
Mail	54.1
Telephone	4.5
TWX	0.8
Search by Borrowing Library	28.6
Courier	12.0
Requests Filled at WSL	67.8
Requests Finally Filled	79.1
Original Material Sent	79.8
Photocopy Sent	20.2
Reasons Unfilled	
Not Owned	63.3
In Circulation	10.0
Missing	3.3
Patron Cancelled	6.7
Inadequate Citation	16.7

TABLE 39 (Cont.)

ANALYSIS OF REQUESTS RECEIVED
AT WSL
(n = 149)

Characteristics	%
Material Transport	
Mail	88.3
Courier	11.7
Originating Library	
East	21.5
West	78.5
Originating Library Type	
Community Colleges	5.4
Public Colleges & Universities	6.7
Private Colleges	2.0
Public Libraries	69.8*
State and Federal Agencies	1.3
State Institutions	10.8
Medical Libraries	2.0
Business and Industry	2.0
Second Referral Source	
East	0.7
West (inc. PNBC)	99.3
Next Referral After WSL	
PNBC	72.3
Academic	6.4
Public	10.6
Special	10.6
Number of Requested Libraries	
1	66.4
2	14.8
3	12.8
4	4.0
5	2.0
Known Location	38.9
Location Not Known	61.1

*One district library accounts for 30.1% of total receipts.

Table 40

WSL RESPONSE TIME *

		No. Cases	Mean Days	Range
Unfilled	25.1%	47	2.17 days	0-19
Filled	67.9	127	4.09	0-33
Reserved	7.0	13	12.76	0-31
Overall	100.0%	187	4.21 days	0-33

*Data from 1,496 cases-only 187 of the 552 requests referred to WSL had data for all parameters required for this analysis.

FIGURE F

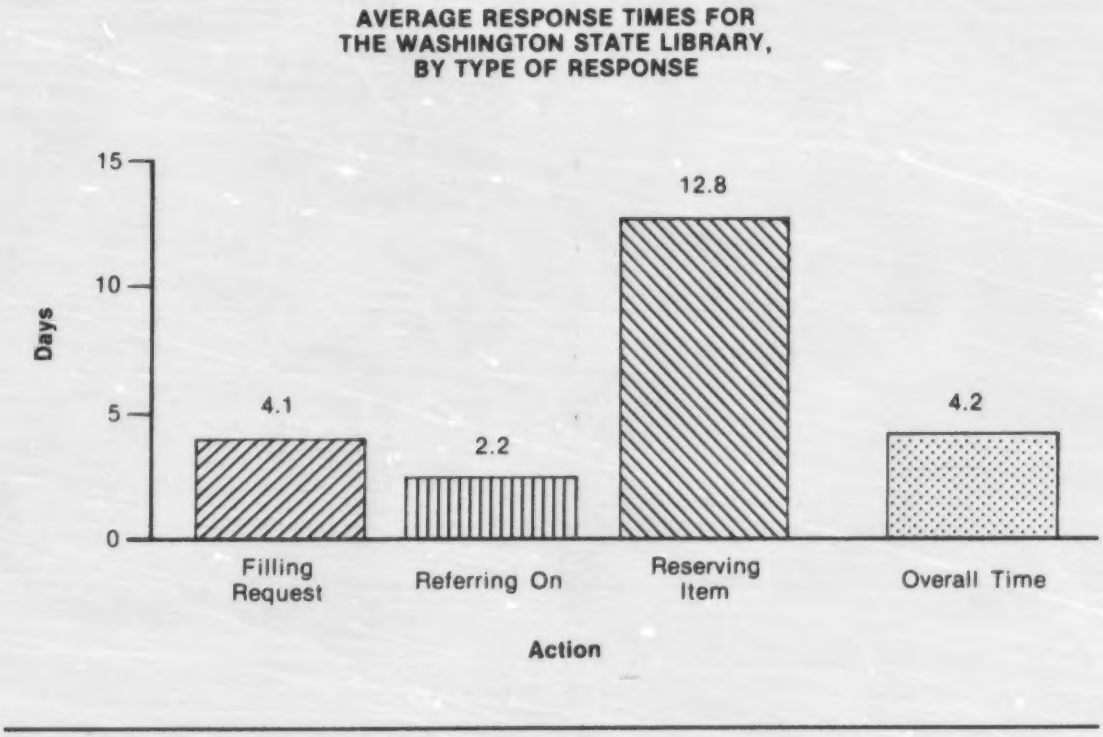


TABLE 41

COMPARISON WITH DATA FROM 1969 STUDY

REQUESTS RECEIVED AT WASHINGTON STATE LIBRARY

Publication Dates	1969	1977
Latest 10 years	52.2%	70.0%
" 20 years	68.9	80.0
" 30 years	77.9	85.8
" 40 years	93.6	86.7
" 50 years	96.0	90.0
" 60 years	97.5	95.8
" 70 years	98.8	99.2
Classification of Requested Items		
000	1.0%	5.2%
100	11.5	5.2
200	3.9	2.6
300	20.8	15.6
400	0.9	-
500	5.3	2.6
600	23.0	32.5
700	10.0	22.1
800	9.0	5.2
900	14.5	9.1

PACIFIC NORTHWEST BIBLIOGRAPHIC CENTER

The Pacific Northwest Bibliographic Center was founded in 1940 under a Carnegie grant and was for many years supported by libraries of Alaska, Idaho, Montana, Oregon, Washington, and British Columbia. In 1970 the method of support shifted from individual library subscriptions to state/provincial level, in order that all libraries in the region might utilize PNBC's services. For the 1978-79 budget, support was apportioned according to relative use of PNBC during 1977-78, and the respective contributions were as follows:

Alaska	$ 27,800	8.4%
British Columbia	7,900	2.4
Idaho	15,900	4.8
Montana	70,700	21.4
Oregon	17,800	5.4
Washington	190,300	57.6
	$330,400	100.0%

PNBC has built up and maintains a union card catalog of materials held by some 45 libraries in the region. The Center's prime mission is to provide one or more locations when possible for each interlibrary loan request, and to route the request to the first referral library. The fact that the Center is located in the Suzzallo Library at the University of Washington has led to the PNBC staff's retrieving UW materials as well as photocopying UW items for requesting libraries. A picture of PNBC's growth in the last 10 years is shown in Table 42. Trends for these parameters over a ten-year period are shown in Table 43. Sources of PNBC-routed requests are shown in Figure G, and a comparison made with 1969 sources.

Of all requests originating in the State of Washington, 26.7% go to PNBC as first, second or subsequent referral, more as second than as first. Of those requests received at PNBC from Washington libraries, 25% are filled by PNBC using University of Washington materials. These, along with those filled by Washington libraries either directly or after PNBC referral, constitute 95.7% of all filled Washington requests. Only 4.3% of filled requests are satisfied out-of-state, whether routed through PNBC or not. (An estimated 7% of all requests are sent out-of-state.)

Only 58% of the requests received at PNBC are referred on to a library. Requests filled by PNBC amount to 23% and requests returned by PNBC unfilled are 19%. When PNBC is the first referral source, it fills 50% of the requests; as second referral it fills none. Photocopied materials comprise 94% of PNBC 'fills'.

Of requests in the sample routed through PNBC, only 17.0% were filled at the first library after PNBC. The reasons why 83% of requests were unfilled at that point are shown in Figure H. The ratio of items not owned or missing (41%) is remarkable, as PNBC almost never sends a request without evidence that the item is held by the first referral library. It appears that the union catalog is seriously out of date for withdrawn and missing materials.

Overall fill rate for PNBC-routed requests was 79.5%; for non-PNBC requests it was 84.1% (see Table 44). This difference may be partly due to the fact that more difficult requests are sent to PNBC.

Of all the requests in the sample which were sent to PNBC, 24.1% were unfilled, 65.8% were filled in Washington libraries, and only 10.1% were filled out-of-state. Thus, $125,217 (65.8% of Washington's contribution of $190,300) paid for the location of items found in Washington State. To put the situation another way: of those requests filled through PNBC for libraries in the state of Washington, 86.7% were filled by libraries in the state (including requests filled by PNBC from University of Washington collections). This would indicate 1) that many Washington libraries are not searching in-state before referral to PNBC, and 2) that as more locations for items become known to more li-raries through the Washington Library Network, Washington's proportional use of PNBC (and corresponding financial commitment) can be expected to diminish.

Requests routed through PNBC in the sample were referred to no more than 2 subsequent libraries. Of 42 PNBC referrals, 37 or 88% went to only one library after PNBC, and 5 or 12% to two libraries after PNBC. However, as Table 45 shows, when PNBC was the second requested source, 15% of those requests were sent to two subsequent libraries for a total of 4 referrals, making for very expensive transactions.

PNBC's response time is surprisingly long, considering the fact that PNBC's function is primarily to route requests. As shown in Table 46, a request requires on average 6.3 days to clear PNBC; the libraries of Washington maintain an average of 4.6 days. Including time for transmission of request, referral through PNBC adds 30.9% to the transaction time.[7] This delay at PNBC, plus the fact that 90% of requests to PNBC are either filled in-state or go unsatisfied, indicates a need for protocols directed toward filling more requests in-state without use of PNBC.

A study at Boise State University (34) in the fall of 1978 found that requests teletyped to PNBC averaged a turnaround time of 14.37 days.

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[7] The Washington figure in an earlier study (Taylor, 74) was 13%. Also see Figure I for comparison with 1969.

On inquiry as to the discrepancy between that figure and this study's average of 28.8, it was learned that the BSU figure does not include non-filled requests (which usually absorb extra time). Neither does it include in-house time before the request is sent out--a time which averaged 12.4 days in our study, for academic libraries. Additionally, there is no mail time in the BSU figure. Therefore, it seems the BSU time would equal or exceed our study's time if the two were made comparable. The Boise State study found a fill rate of 97% for requests sent to PNBC; BSU investigators report that they cannot explain the current data, as the figure over past years has been 80% to 87%.

It is possible that PNBC's over-long average response time is affected by PNBC's efforts to fill requests using the University of Washington's resources. It would seem more effective for PNBC to apply its resources to maintaining the union catalog, and searching the union and UW catalogs -- fulfilling its switching function and escaping the production function by referring to the interlibrary loan office of the university the items which can be filled there. These PNBC-filled requests cost the State of Washington $43,388 (22.8% of $190,300) in 1976-78. This amount (or less) might better be allocated to maintain speedy service through the university library, perhaps by financing a position (or two) to serve the state's needs.

Publication dates of items requested through PNBC are shown in Figure J. There has evidently been been no large change over the past ten years.

There has been a marked shift in the ratio of books to serials requested, as seen in Figure K. The proportion of requests for serials has doubled, probably due to PNBC's practice of photocopying UW materials at no charge. Many libraries utilize PNBC to avoid UW's photocopy fee.

When PNBC is the first referral source, it fills directly 50% of the requests, 94% by photocopied materials. As second referral it filled no requests in our sample. Again, a better solution might be a state subsidy to reimburse the university for photocopying, so that these requests can take their normal course through the university's interlibrary loan office. Another alternative might be to supply a photocopier in the university's interlibrary loan office. PNBC could then concentrate on its main mission of locating materials.

A significant burden in PNBC's operation is the maintenance of the union card catalog, which has grown so large that interfiling is extremely time-consuming. It would be reasonable for PNBC to cease filing cards from any library inputting its current acquisitions to the Washington Library Network, since PNBC has terminal and microfiche access to those records.

A cost benefit study of the Midwest Medical Union Catalog (Olson, 47) resulted in the recommendation that the current catalog be maintained at a minimal level while looking toward emerging computerized data

bases to provide locations more effectively. Experience in Ohio indicates that the state-level interlibrary loan switching center established at Ohio State University in 1969 has run a cycle from the 7,126 requests in 1969-70 to a peak of 13,810 in 1972-73 and then a steady dwindling to the 6,389 requests tabulated in 1977-78. Mary Ellen Page, IULC-RAILS Librarian (87), writes, "We do not know the specific cause of this decline, although OCLC and the formation of other consortia in this state have no doubt had their effects."

Even more closely analagous to the Washington situation is a report from the Bibliographic Center for Research in Denver (4): "The Regional Union Catalog, a valuable tool, can no longer be added to economically (i.e., it requires extensive filing, coding and blending of cards)." The report further indicates that new methods for facilitating interlibrary loans must be developed, that centralized card catalogs are no longer competitive with the in-library terminal or microform access to holdings data bases. Simpson sees the beginning of a transition from large scale regionally centralized processing to local and state level processing of interlibrary loans, based on automated services.

The basic PNBC concept should be scrutinized. With a budget of $330,400, and a contribution of $190,300 from the State of Washington, given the problems described, PNBC may have become no longer cost beneficial. A regional bibliographic center maintaining and operating a union card catalog was at one time a fine answer to a pressing problem; now there are indications that it is becoming anachronistic.

TABLE 42

COMPARISON OF PNBC WORKLOAD

1967-68 and 1977-78

	1967-68	1977-78	Ratio 1977-78 / 1967-68
Staff FTE	6	14	2.33
Operating Budget	$ 43,797	$293,962	6.71 *
Requests Received	19,368	90,360	4.67
Cards Received	265,238	382,279	1.44
Photocopies Supplied	-	25,960	-
Requests per FTE	3,228	6,454	2.0
Cards per FTE	44,206	27,306	0.62
Cost per Request	2.26	3.25	1.44 *

*Consumer Price Index Inflation Figure = 4.1

TABLE 43

PNBC: COMPARISON AMONG STUDIES

Study	Parameter		
	Fill Rate	% of Unfilled Referrals Missing or Not Owned	Photocopies ÷ Requests
Currier 1969			4%
PNBC Spring 1972		35.2%	
PNBC Spring 1975	81%	21.3%	
This Study 1977	80%	56.9%	31%
PNBC 1977-78			29%
BSU * Feb. 1978	82%		
BSU Oct.-Dec. 1978	97%		

*Reported from Boise State University, Idaho
Unpublished Manuscript

FIGURE G

SOURCES OF REQUESTS RECEIVED AT PNBC FROM WASHINGTON LIBRARIES

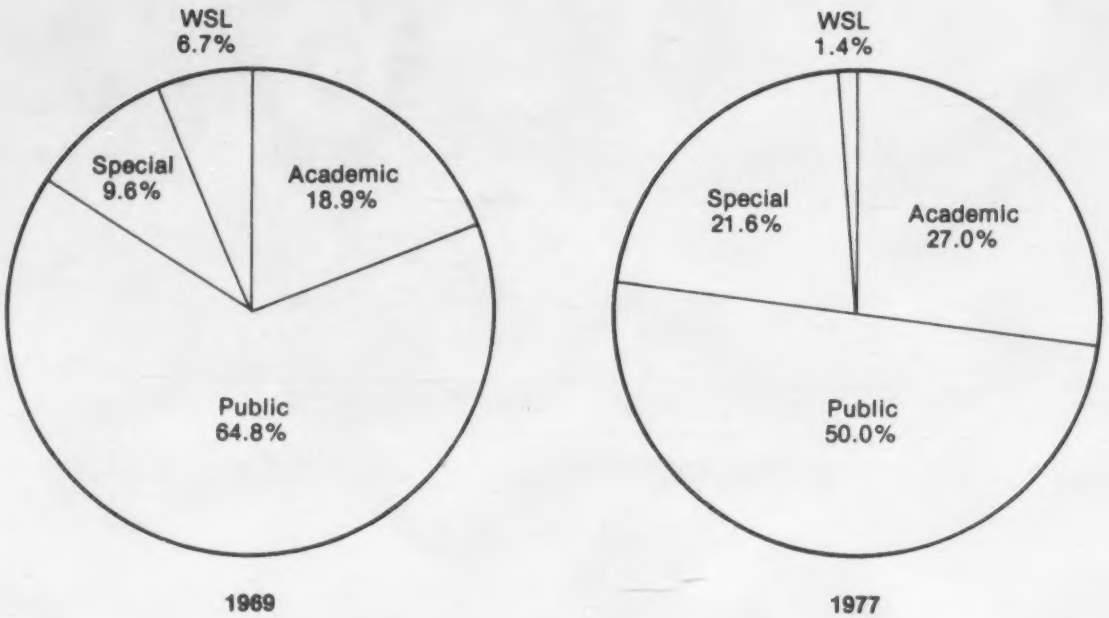


FIGURE H

REASONS WHY REQUESTS THROUGH PNBC ARE NOT FILLED BY THE NEXT REFERRAL LIBRARY

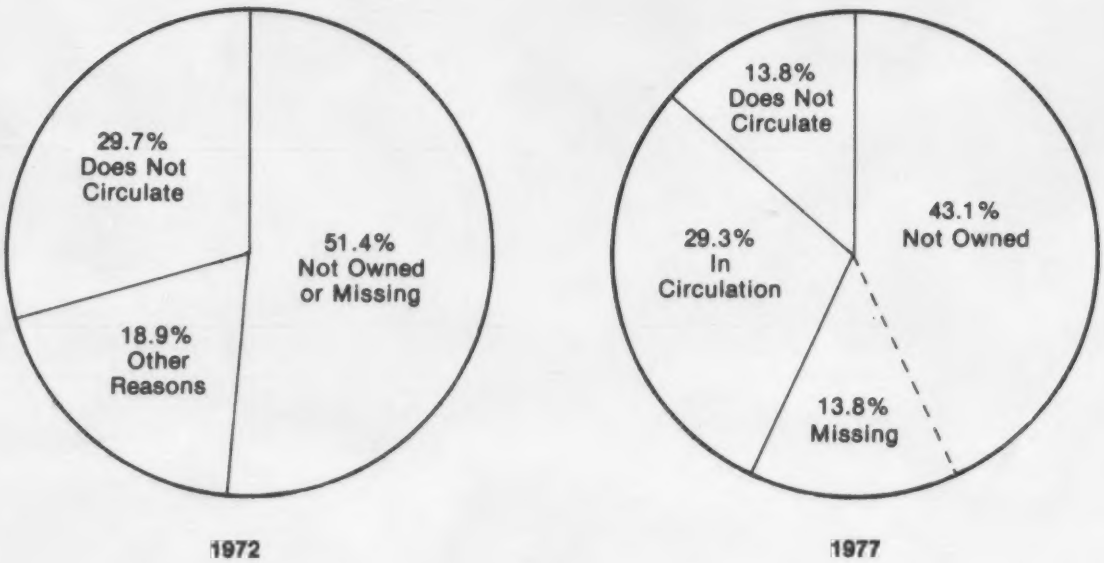


TABLE 44

RATIO OF FILLS FOR
PNBC-ROUTED REQUESTS

Final Disposal	Request to or Through PNBC	Requests not to PNBC
Filled	79.5%	84.1%
Not Filled	20.5%	15.9%

TABLE 45

NUMBER OF REFERRALS AFTER PNBC

	1	2	3
PNBC as Library 1 --	12	1	0
PNBC as Library 2 --	23	4	0
PNBC as Library 3 --	1	0	0
PNBC as Library 4 --	1	0	0
	37	5	0

TABLE 46

PNBC RESPONSE TIMES *

Response		No. Cases	Mean Days	Range
Returned, no location	13.2%	59	12.9 days	0-151
Filled	51.7	231	5.27	0-43
Referred	35.1	157	5.42	0-52
Overall	100.0%	447	6.3 days	0-151

*Data from 1496 cases--only 447 of the 629 requests referred to PNBC had data for all parameters required for this calculation.

FIGURE I

TIME FOR COMPLETING PNBC-REFERRED REQUESTS
Patron Request Date to Receipt of Material or Non-Fill Notice

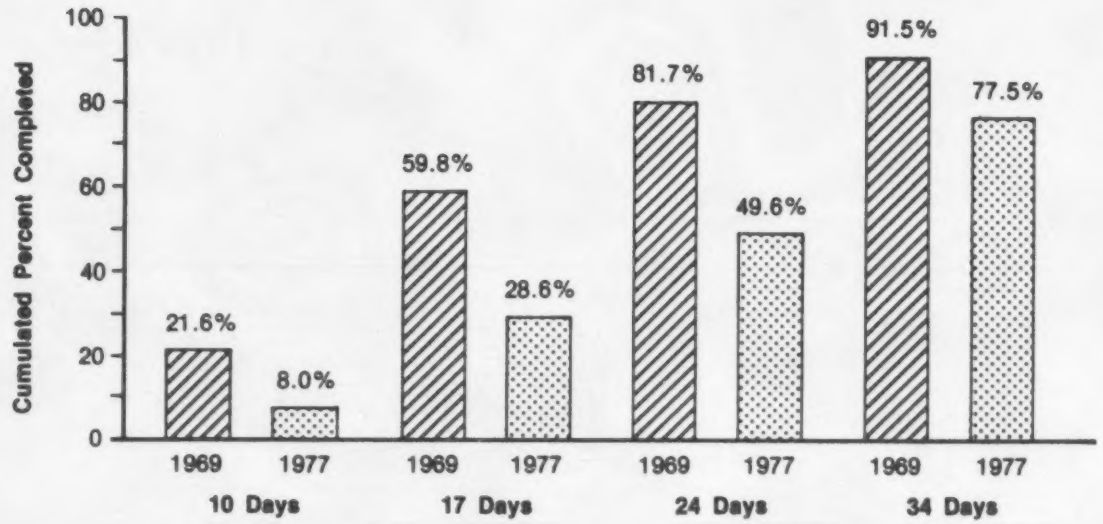
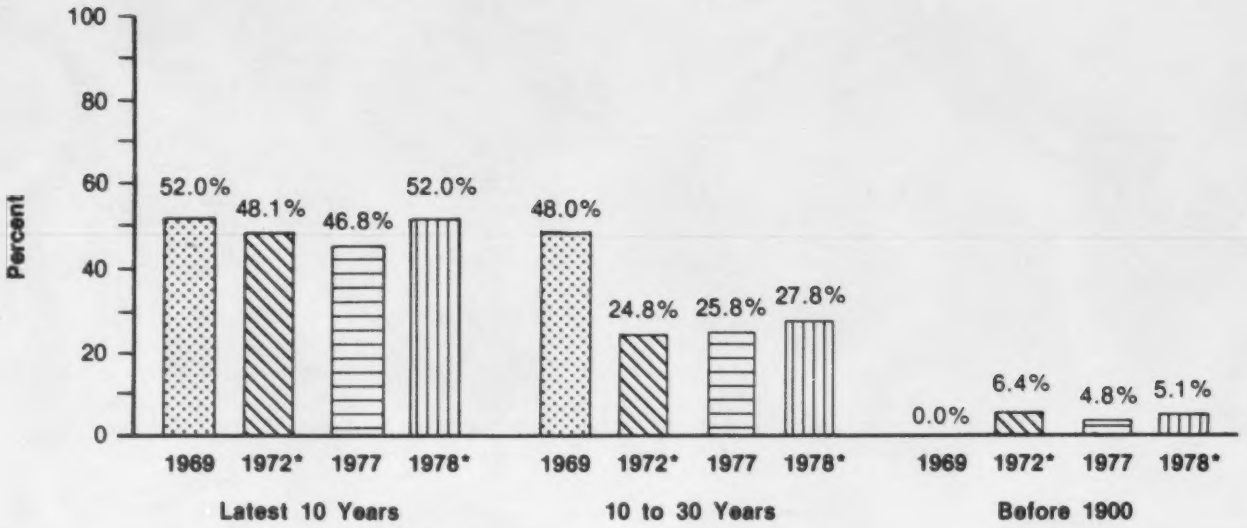


FIGURE J

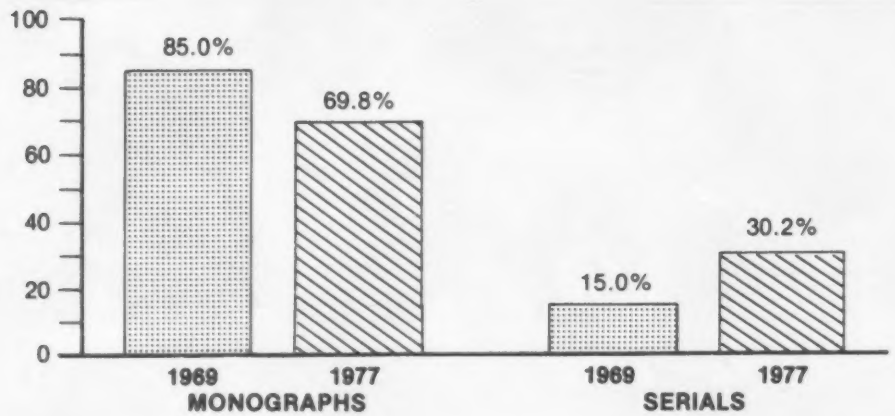
COMPARISON OF PUBLICATION DATE ON REQUESTS SENT TO PNBC*



*PNBC studies 1972 and 1978 include all states; 1969 and 1977 studies reflect Washington only.

FIGURE K

COMPARISON OF MONOGRAPHS/SERIALS REQUESTED VIA PNBC



WASHINGTON LIBRARY NETWORK:

THE COMPUTER/COMMUNICATIONS COMPONENT

Anticipating the impact of new technology upon old service processes it occurred to the investigators that the application of new technology might be change but it was not necessarily progress. If the development of a computer-managed and telephone-linked analog for a union catalog was not done using premises that allowed organization and product flexibility, a burden might be put upon the interlibrary loan component of WLN that would eventually cost bind the activity as well as bankrupting WLN. To determine on a comparative basis the utility state of WLN models were developed of several existing types of bibliographic data base organizations. Simulations were run measuring the patterns of storage and communications growth, ease and adequacy of access and costs associated with these activities.

Results indicated that Washington Library Network's computer data base component is the most efficiently organized, least costly, and has the lowest storage growth characteristics of those devices modeled. Communications costs proved not to be a limiting factor as traffic density increased, while storage requirements appear to be structure dependent. Figure L illustrates some parameters of the simulation.

```
* ASSUMPTIONS                FIGURE L
*
* EACH DATA BASE CONTAINS 2 MILLION RECORDS.
* 1000 LIBRARIES REPRESENTED AS LOCATIONS; 200 LIBRARIES PER
*     AUTHORITY GROUP.
* CPU PROCESSING RATE: 100 CHARACTERS PER MILLISECOND
* CPU PROCESSING TIME: LC =  11,200 MS.
* FOR COMPLETE DATA    U1 = 255,000 MS.
* BASE SEARCH          U2 = 219,000 MS.
*                      U3 =  18,600 MS.
* COMMUNICATION FACILITY: 1 CHARACTER PER 8.3 MS.
*
* TRANSACTIONS:     SEARCH DATA              CREATED DATA
*                  15,000/WEEK              2500/WEEK
*                    3000/DAY                500/DAY
*                     325/HOUR              62.5/HOUR
*                    6.25/MINUTE           1.042/MINUTE
*                 1 TRANS/9600 MS.         1 TRANS/57,600 MS.
*
* LC RECORD = ABL (UNIT RECORD WITH APPROPRIATE INDICES)
*             (A = AUTHORITY ELEMENT, B = BIBLIOGRAPHIC
*              ELEMENT, L = LOCATION ELEMENT)
* U1 RECORD = ABL X 5 AUTHORITY GROUPS
* U2 RECORD = ABL + 4 ADDITIONAL A AND L ELEMENTS TO ACCOMMODATE
*             5 AUTHORITY GROUPS (MODIFIED UNIT RECORD)
* U3 RECORD = B + 5 AUTHORITY FILES + LSUB1 AND LSUB2
*             (QUADRAPLANAR STRUCTURE)
*
* LC STORAGE REQUIREMENTS FOR 2 MILLION RECORDS:     1,120,000,000 BYTES
* U1 STORAGE REQRMNTS FOR 2 MIL RECORDS X 5 GROUPS: 25,500,000,000 BYTES
* U2 STORAGE REQRMNTS FOR 2 MIL RECORDS X 5 GROUPS: 21,900,000,000 BYTES
* U3 STORAGE REQRMNTS FOR 2 MIL RECORDS X 5 GROUPS:  1,860,050,000 BYTES
*
* LC AVERAGE CHARACTERS/RECORD ABL (1 LOCATION) - 560 CHARACTERS
* U1 AVERAGE CHARACTERS/RECORD ABL X 1 AUTHORITY GROUP (200 LOCATIONS)
*     = 2550 CHARACTERS
* U2 AVERAGE CHARACTERS/RECORD ABL MODIFIED X 1 AUTHORITY GROUP
*     (200 LOCATIONS) = 2550 CHARACTERS
* U3 AVERAGE CHARACTERS/RECORD B + ASUB1 + LSUB1 + LSUB2 + 1 AUTHORITY
*     GROUP -- NOT APPLICABLE
*
* COST PER STORAGE = $0.0006/BYTE
*     LC = $   672,000          2.2%
*     U1 = $15,300,000         50.6%
*     U2 = $13,140,000         43.5%
*     U3 = $ 1,116,030          3.7%
*  TOTAL = $30,228,030        100.0%
*
* 1000 LOCATIONS: CHARACTERS PER LOCATION/RECORD
*     LC = 560
*     U1 =  12.75
*     U2 =  10.95
*     U3 =   0.93
*
* COST FOR STORAGE PER LOCATION/RECORD
*     LC = $0.336
*     U1 = $0.00765
*     U2 = $0.00657
*     U3 = $0.000558
*
* U3: 8 MILLION TITLES, 4000 LIBRARIES, 4,280,200,000 BYTES
*     OF STORAGE = $2,568,120 FOR STORAGE
```

CAVEAT! CAVEAT! These are not real life figures; they are in no way to be construed as representing the real world. They are theoretic and are used only to make various types of data base management system comparable.

MODELS AND SIMULATION

Complexity arises from the relationship between the components of a system and its process algorithm. When the interdependency of components and state variables cannot be fully described by analytical expressions nor reduced to easily solvable functions, an analog with which to simulate a real world situation may be a useful tool. It can aid in problem definition, factoring relationships which influence design, measure sensitivity to the change of system load parameters, predict alternative systems' performance, and aid in selection of final design from among alternatives.

The representation of the system, its rules and relationships, is defined as the model. The exercise of the model under various specific conditions is defined as simulation.

Once confidence has been established that the model is a valid description of the real system, a series of parametric simulations can be run to gain understanding of system behavior and to gain feeling and insight into the effect of proposed changes that only system manipulation and operation could otherwise provide.

For the purpose of this study, the interlibrary loan models were constructed from data collected in 1977-78. Programs were built using the General Purpose Simulation System (GPSS), and were run on an Amdahl 147/V6 computer. GPSS performs logical operations to simulate the flow of events through processes in time dimensioned actions. Program listings and output are included in this report.

Comparison of the simulation results with actual operations of the interlibrary loan system provided validation of the model. To determine the most efficient operation, different sets of process timings were used against a standard workload, which was calculated on the basis of both experimental and historical statistics. The following runs simulated both the statewide service situation, and internal library processing. Each computer run simulated the operation of a specific aspect, but does not include tasks directly related to acquisitions, catalog production, and administration. These supporting functions were analytically modeled and the data incorporated in the computer model as ancillary factors.

Simulation generated information can assist in defining optimum approaches to service for the State of Washington. Should decision-makers require additional information, the computer programs are stored and readily available for further use. For example, if the administrator or funder of one of the present borrowing or lending libraries should consider changing its service reponsibilities, new data can be input to the model(s) to forecast personnel, costs, or procedures alterations. The models can be adjusted to note change and its effect. The models can be used in a variety of situations; the input data must be derived for each in terms of demographic,

library, geographic, postal, etc., factors. It is necessary to rewrite or modify a model itself only if some different pattern of relationships is planned.

A properly documented case study of a simulation will contain the following components:

1) Statement of problem

2) Model building approach

3) Table of definitions

4) Block diagram

5) Program listing

6) Program output

7) Discussion of model logic, model implementation, and program output.

GPSS Description

A GPSS model can formally be considered a set of interrelated logical and mathematical symbols which represent those aspects of a system which are of interest. Each model consists of various elemental abstractions by which the system is represented. Each of these entities has associated with it a set of attributes that describes the performance of the system being modeled.

GPSS has 14 entities with which models can be constructed: blocks, transactions, facilities, storages, logic switches, arithmetic variables, Boolean variables, functions, queues, frequency tables, savevalues, matrix savevalues, user chains, and groups.

Each transaction possesses parameters as its key attributes. These attributes have a variety of interpretations which are determined by the user.

In this study our concern has been basically with a class of systems called queueing or waiting line wherein events occur over a time sequence. When this sort of system is modeled, the various categories of events which can occur must be identified and the effect each has on the system state must be assessed. The model must then be constructed to allow these events to occur and to update the state as a consequence of their occurrence. To develop the simulation, two logical requirements must be observed: 1) event times must be consistent with the independent variables which govern system behavior; 2) events must be caused to occur in the proper chronological sequence. Events must be categorized as either primary or dependent. A primary event is one whose time is scheduled in advance of its actual occurrence. Dependent events occur as a direct result of a primary event. They are primary

event dependent. To enable model control, tables are developed for scheduling events. Future as well as current events are specified.

Descriptions of the unique characteristics of events are contained in parameter catalogs. Algorithms describing change within logical relationships and for collecting and arranging data concerning the simulation are provided. Plans for varying simulation time and model element interconnections are developed to determine when or if a system is capable of steady state. Simulation result details of special interest are 1) the number of transactions during a given time span 2) the characteristics of transaction queues 3) the utilization of facilities that service transactions 4) tables detailing aspects of event occurrences.

In GPSS many of the programmatic devices such as random number generators, real and simulated clocks, automatic clock maintenance, event priority assignment, automatic gathering of statistics, capability for defining and sampling from empirical distributions as well as well known distributions such as the Poisson, exponential, normal, etc., make the task of model building much easier than when a standard procedural computer language such as FORTRAN or PL/1 is used. GPSS is in effect both a language and a program. As a language it is well defined with specific vocabulary and grammar with which certain types of systems can be unambigously described. As a computer program, it interprets the model, thereby making it possible to conduct experiments on a computer. GPSS models are built by selecting statements and arranging them in an order that describes the meaningful interaction of model elements. The logical requirements of the system being modeled dictate which statements or types of statements are used in the construction. When the simulation is implemented, it is the interaction among the statements which is analagous to the interaction of elements in the real system being modeled.

Models in Study

Although many models in many versions of simulation programs were developed and used during the course of this report, the catalog of programs was eventually reduced to five. Three of them relate to the internal processing of a library, one relates to the interlibrary loan system itself and the actions of borrowing and lending libraries within this context, and one pertains to both levels.

The five models can be described as follows:

1) MODILIN1 gives a quick look at local lending library processing times for both filled and unfilled requests.

2) MODILIN gives a more rigorous look to determine the lending library's processing capability in relation to the traffic received. WSL data are used in the sample run. Both MODILIN and MODILIN1 are tools for the manager of the lending library.

3) MODILBL is a tool for managers of individual libraries to analyze both lending and borrowing processes (Sections 1 & 2). It offers a quick look at the characteristics of requests received or sent. The manager can match these characteristics against his knowledge of the collection to determine any recommendations for alternative routings of requests.

4) MODILIN2 is a tool for both local library and network managers. The local manager can select the section of the program most nearly representing the search facilities of his library and study how requests flow outward. This program is also capable of being made rigorous enough to evaluate the adequacy of processing at an individual lending institution. On the network level, a manger can use the program to look at the entire traffic flow.

5) MODILEX simulates the flow of requests on the network level and can be useful to the network manager or network-level committees on interlibrary loan protocals. The four sections of the program trace the flow of requests originating in A) college and university libraries, B) community college libraries, C) public libraries, and D) special libraries.

Although tables of definition, block diagrams, program listings as well as samples of output are provided in the users' manual for all programs, only one (MODILIN 2) is described here to exemplify the premises and logic upon which model and simulation are predicated.

With this program a mechanism is provided for assessing the impact of particular types of libraries on the interlibrary loan system. A major premise is that a library can be categorized by the type and capability of its bibliographic tools, and by its performance as a storage or switching device. The program explores alternate policies, structural procedures, and performance measures. Four categories of libraries are posited, ranging from those with only rudimentary bibliographic tools to those with online data base access. The simulation assesses the action of each type of library as it responds to a request to borrow. It assesses response to request types containing varying degrees of completeness of bibliographic data. It assesses response when a library determines that it does not own the desired item, but switches the request to another institution. Some institutions such as the Pacific Northwest Bibliographic Center operate mainly as switching centers, containing essentially only location data for the region. The impact upon such institutions of the computerized union catalog which is developing at WLN upon such institutions is investigated. Model relationships are predicated upon data developed during the initial study phases which indicated that institutions tended to borrow from like institutions if they had appropriate information. Second choice was a large switching center such as WSL and PNBC. The model is constructed to enable network managers to assess potential traffic loads and origins and to enable an individual library manager to predict his institution's effect on the system as well as the system's effect on his institution. Output contains estimates of the time

requests remain in the system before resolution, as well as data concerning the number of personnel needed to process requests at various levels of activity.

Model Logic

A transaction representing a request to borrow an item is generated. If the model is being used to represent a particular institution, the rate of generation is based on a probability function that describes that library's experience as a lending facility. If the model is being used to simulate an entire network, transactions generated would reflect traffic from many sources. The transaction passes through processing stations that are analagous to real world events; it is this ability that provides the capability of testing alternate processing constructs. Data concerning these events are printed as part of the program output which consists of a listing of the assembled model, symbol dictionaries, real and simulated time clock values, block counts, event statistics, and inferential tables concerning facility utilization and queues. Graphical representation is also possible as are calculations to assist in cost/benefit analysis. Output interpretation demands an understanding of simulation premises and an awareness of probability of coincidence of the analog to the real world system.

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a network management tool:

computer simulation of interlibrary lending

II: A User's Manual for Models

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0.0 Preface

These models were developed under funding from the U. S. Office of Education, Library Research and Demonstration Program. The project has been co-directed by Hugh T. Vrooman, Illinois State Library, and Mary Jane Pobst Reed, Washington State Library. The work was begun in October 1977 and completed in March 1979.

MODIL USER'S MANUAL

1.0 Introduction

The function of this part of the report is to give library managers, nonprogramming users, systems analysts, and programmers sufficient information about the MODIL programs for adjusting programs to different specific situations, inputting data, and running the programs.

This introductory section provides the user with an overview of the programs so that he will have a general impression of what they are and how they work.

MODIL is a set of five computer models developed for simulation of interlibrary loan flow, on the statewide level and within a participating library. While the immediate simulation is for the state of Washington, the models can be utilized to represent any number of libraries and any geographic area desired. The simulations are directed toward providing information which can assist management in decisions relative to interlibrary lending policies and protocols.

The state-level models simulate types of libraries, with requests and materials flowing among the libraries. Times of flow and in-library processing are simulated, as well as filling and nonfilling of requests. By adjusting the model parameters, the effects of various inter- and intralibrary procedures can be studied.

The intralibrary models simulate the internal interlibrary lending/borrowing operations, permitting managers to study alternative staffing and procedural patterns, and identify subsequent bottlenecks. The model constructed to simulate internal borrowing and lending processes (MODILIN) is used for illustration throughout this manual, except when discussing aspects which are only to be exemplified in other models.

The five models can be described as follows:

1) MODILIN1 gives a quick look at local lending library processing times for both filled and unfilled requests.

2) MODILIN gives a more rigorous look to determine the lending library's processing capability in relation to the traffic received. WSL data are used in the sample run. Both MODILIN and MODILIN1 are tools for the manager of the lending library.

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3) MODILBL is a tool for managers of individual libraries to analyze both lending and borrowing processes (Sections 1 & 2). It offers a quick look at the characteristics of requests received or sent. The manager can match these characteristics against his knowledge of the collection to determine any recommendations for alternative routings of requests.

4) MODILIN2 is a tool for both local library and network managers. The local manager can select the section of the program most nearly representing the search facilities of his library and study how requests flow outward. This program is also capable of being made rigorous enough to evaluate the adequacy of processing at an individual lending institution. On the network level, a manager can use the program to look at the entire traffic flow.

5) MODILEX simulates the flow of requests on the network level and can be useful to the network manager or network-level committees on interlibrary loan protocols. The four sections of the program trace the flow of requests originating in a) college and university libraries, b) community college libraries, c) public libraries, and d) special libraries.

This users' manual is composed of six sections, including this introductory overview. The second section describes collection and input of data to define transaction load, request characteristics, transmission and processing times, lending and borrowing library types, and probability of filling requests. The third section describes the running of a model, and the fourth is concerned with interpretation of model outputs. The fifth and sixth sections display flow diagrams and definitions, listings, and sample outputs of the models.

This manual is written primarily for the use of libraries in the state of Washington, with access to the Amdahl 470/V6 computer in Pullman, WA, where MODIL is stored. These specific instructions can be translated for different hardware and software. The instructions for input and the interpretation of outputs will be applicable anywhere.

In order to utilize a model, the user must furnish certain data describing the specific situation to be simulated. These data are discussed in Section 2. Where data on the situation are unavailable, estimates based on experience may be substituted.

The model is written in General Purpose Simulation System/360 language and can be operated on any computer with an appropriate GPSS package. Users in Washington State (and elsewhere, with proper access) may use the programs now resident in State Data

Processing Center #3 in Pullman. In addition to operating the programs as described in this manual, the Washington user would find it useful to have at hand a manual on WYLBUR which is utilized for remote input of data to modify programs and to run the models. Advice and tutorial assistance are available from the authors for initial use of the models.

1.1 Interaction with MODIL

The segment of the program requiring specific data for each situation is marked off by brackets. It is not necessary for the user to understand the details of the coding; if desired, the GPSS/360 users' manual can be consulted (IBM publication GH20 0326-4).

The basic form of each command is a name (optional) in the location field, columns 2-6; the command name in the operation field, columns 8-17; and A-I fields, separated by commas, in columns 19+.

1.2 Beginning and ending the use of MODIL

At time of logging onto the computer, the user specifies use of the MILTEN system, which provides the WYLBUR text editor. Then the program to be used is called for. The sequence should be as follows (parenthetical sections will vary for each user). The '?' or 'COMMAND?' are computer-supplied prompts which indicate expectation of a user response. Appropriate response will vary with the immediate context.

We have adopted the convention of underlining user response; non-underlined statements are computer-generated.

1.2.1 Beginning use of programs

User: EE -Carriage Return (CR)

Computer: ??

User: MILTEN - (CR)

Computer: Account?

User: (account number, initials) - CR

Keyword?

(keyword)

??

USE MODILEX (or MODILIN, etc.) USER MJR GRO LN ON WLN001 (CR)

??

At this point the program has been copied into the user's active file and can be altered, data can be input, and/or the program run.

1.2.2 Ending use of programs

If user wishes to store his version of the programs and data for future use, a library on disk must have previously been set up through WLN, and instructions obtained for storing and retrieving. Otherwise, the usual signoff procedure (or calling up another program or system from the computer) will complete the use of the program, in which case the next usage will begin as above with the stored MODIL programs on WLN001.

1.3 Data to be input

Simulation requires a clear definition of the problem and of the quantitative characteristics involved. Where careful measurements are not possible or are too expensive, educated estimates can be satisfactory. Each function is based on probabilities; for example, in our sample model (page 6.2-1, cards number 10-11) the first function determines the type of request. As defined for WSL, 5.4% of requests will be for periodicals, 20.8% subject requests, and 73.8% for author/title. These proportions might be based on estimates provided by interlibrary loan clerks, by a count of actual requests over a period of time, or by some other method of arriving at a reasonably sound set of data. Similarly, the time absorbed in performing a specific task such as photocopying must be established by guess or by direct measurement; in the case of our example model (cards number 16-17), the range is 30 to 600 seconds with an even distribution of cases throughout the range.

Another type of data which must be supplied is related to flow of materials. In the example, we see on card 121, a transfer command, that 10% of incoming requests will be for government documents and will be referred to the specialized staff, while the remaining 90% will be searched in the public card catalog and/or the WLN terminal.

Specific data to be used will be determined by the problem being simulated and the type of solution being sought.

2.0 Inputting data

The text editing program WYLBUR is utilized to change the stored program to fit a specific situation to be simulated. Data which might be adjusted is in general located in the functions, the variables, the table definitions, or the run regulation segments of the program. Each of these is described in detail in the remainder of this section.

2.1 Definition of functions

The functions provide a basis for computer computation of data to specify parameters for transactions and operations of the model. In most cases, the calculation is based on use of random number generators to determine on the basis of probabilities which of several characteristic options will be applied to a particular event.

Functions based on random numbers carry RNx (where x = 1 to 8) in columns 19-21. The numeral indicates use of a specific "pseudo-random" number generator--there are eight such available. The B field of the function card specifies the type of function: discrete, continuous list, or attribute valued. The second character in the B field indicates the number of pairs of X,Y values in the function description.

The next line after the FUNCTION command describes the function, whether discrete or continuous, with probabilities for the occurrence of each value. These probabilities must total to 1.000. Then, beginning with the lowest-value alternative, each probability is paired with its value. The probabilities are cumulated so that the first is a span beginning with 0.000 and the last is a span ending with 1.000. If probability is X and there are three values of Y, the pairs will read:

$$X_1,Y_1/X_2,Y_2/X_2,Y_2$$

The probability of Y_1's occurrence will be X_1; the probability of Y_2's occurrence will equal X_2 minus X_1, and the probability of Y_3's occurrence will equal X_3 minus X_2, with X_3 being 1.000.

Functions' X and Y characteristics are established on the basis of real data, if possible, or informed estimates.

The function values utilized in the illustrative runs are derived from the earlier data collection. Subsequent users of the programs will wish to insert values more nearly reflecting their own situation. In MODILBL, MODILIN2, and MODILEX, users will run

only the section of the program most nearly matching their library's capabilities and facilities, or the function (e.g., borrowing or lending) which they wish to analyze.

2.2 Definition of variables

Variables are expressions of data specifications to be processed by arithmetical or logical operators. Data can be specified either directly or indirectly; arithmetic operators are add, subtract, multiply, integer division and modulus division. Boolean variables consist of references to logical conditions and combinations of the simulation elements and events, especially equipment-oriented entities. Logical operators are logic switch set/reset, facility in use/not in use, storage full/not full, storage empty/not empty.

An arithmetic variable is defined by the location, operation and operand fields of the Variable command. The name of the variable is placed in the location field; the word VARIABLE is entered in the operation field; the arithmetic expression is set in the operand field which must be located in columns 19 to 71.

In the sample model, the variable is used to calculate the time for processing periodical requests (card number 76, page 6.2-2). Parameter 8, which is defined by function PRCT2 (public catalog search time) is added to parameter 11 which is PRCT5 (verification time), and the total divided by 2 then added to parameter 10 which is PRCT4 (stack search and retrieval time).

Variables can also be defined in floating point and in Boolean style, though these types are not used in the present models.

2.3 Definition of tables

Tables are defined by fields A to E of the TABLE command.

A defines the tabulation to be made. For example M1 will cause tabulation of the time in program for each transaction from its creation to the TABULATE block.

B defines the upper limit of the lowest interval.

C defines the interval width.

D defines the number of intervals.

E defines the arrival rate time interval.

In using the present models, it is advisable to run the model first with the tables as defined in the stored program, then make adjustments if necessary for later runs.

In the example model, table ATP (card number 69) is defined as the time interval from the beginning of the program to the table position (card number 156). The first interval spans from 0 to 100, each of the other intervals spans 200, and there are 10 intervals; the table is to record the number of arrivals during each of the 11 time units. The resulting table is shown on page 6.2-5; note that the mean, standard deviation, and sum of arguments are provided, as well as the frequency distribution.

2.4 Regulating transaction load

The GENERATE command at the beginning of the program (card number 94) regulates the frequency of transactions. The unit of time on which MODILIN is based is one second (card number 7). The sequence of numbers in the operating field is separated by commas:

> A determines the average time between transaction entering the program.
>
> B sets a range on both sides of A for scattering of entry times, using a random number generator. B must be less than A, to avoid occurrence of a negative number.
>
> C can set a limit to the number of transactions. If blank, transactions will be created indefinitely--in this model, until the "run timer" at the end of the program stops operations.

The program at present is set to create one transaction every 0 to 180 seconds (see Function GEN1, card numbers 32-33). A change of A and/or B field or in the function definition will change this frequency as desired.

2.5 Regulating model simulation time

Model simulation time is controlled by the GENERATE-START-TERMINATE sequence at the end of the program (cards number 211-213). The GENERATE block defines the number of simulation time units to be counted, the START block defines the number of times this set of units is to be repeated, and the TERMINATE BLOCK counts repetitions and terminates the run when the indicated time has been simulated. Thus, if the time unit is one hour, then when the commands read

```
GENERATE      8
TERMINATE     1
START        20
```

a month's operations will be simulated. TERMINATE tallies 1 every 8 units and START states "stop when 20 of these 8-unit periods have occurred"--or 20 working days.

Similarly, if the time unit is one minute, the commands

```
GENERATE        480
TERMINATE         1
START            20
```

also will simulate a month's operations.

3.0 Running the model

Once all parameters are adjusted for the situation being simulated, the model should be saved in a user library for future use. Actual running of the model is invoked by the following sequence:

User: Run unn ter (CR)
Computer: account?
User: (account number) (CR)
Computer: (indicates status of program in operating queue)
User: (when program has been run): Fetch (program number) save (CR)
Computer: OK TO CLEAR?
User: OK (CR)
Computer: (brings output into terminal for review)

User may inspect the output via terminal and/or may route the program output to a data processing printer for hard copy output.

A single model may be exercised for several simulations in one run by use of the CLEAR card. This card is utilized in MODILEX, p. 6.5-3, with redefinition of whatever cards need adjustment (in this case the function definition for number of referral libraries).

4.0 Interpreting results of the run

When a run has been satisfactorily completed, the output will include the user's preliminary description of the program; function, variable, and table definitions; program listing; symbolic listing; traffic flow data; and statistical reports.

The definitions of functions, variables, and tables, as well as the listing of the program will be as input by the user. Output to be interpreted follows the symbolic listing of the program, starting with a statement of the relative and current clock times and current and total transactions for each block in the program. The following segments of the output are of interest in the user's interpretation of the output.

4.1 Relative/absolute clocks

In the present models both these times will be the same. The time statement must match with the user's requirements, as indicated in the run timer section of the program. In the specimen run (page 6.2-4), the time is 14400 seconds, or one week (5 working days).

4.2 Block counts

The location of any transactions which are in process at the time of termination of the run can be ascertained by scanning the CURRENT column. Total block throughputs can be checked against the program listing to confirm that transactions have flowed as intended. On page 62-4, 1140 transactions were generated; following through the numbered blocks we see that 1140 transactions went through blocks 1-7, at which point 10% of the requests were transferred to block 99, leaving 1033 requests in block 28. At that point the 279 subject and periodical requests are transferred to block 73, leaving 754 monograph requests to be processed. After the on-line terminal search in blocks 29-33, the 258 requests not found are searched in the lending library's public catalog.

Those found, plus those found in the on-line search, are sent for shelf search (blocks 42-46). Items in hand (778) are then sent to be packed and mailed (blocks 48-59).

By following this procedure on through the program, the flow of transactions can be traced to assess the accuracy of the models behavior relative to the real system.

4.3 Facility statistics

Statistics for utilization of facilities are the next item in the output. For each facility the following data are given: average utilization; number of transactions entering; average time per transaction; the identifying number of the transaction being seized by the facility; preempting transaction's number. In MODILIN, (page 6.2-4), the facility call PAKR, which represents the packing and mailing of requested items, has been utilized on average 60.4% of the time. (A rate of 70% is considered full production time for human workers; they are not expected to operate every instant as is a machine. A rate of utilization of over 70% is crisis-building.) There have been 452 transactions passed through the facility, with an average time per transaction of 192.46 seconds. The facility is at the time of termination of the run seizing transaction number 35; there is no preempting transaction.

4.4 Storage statistics

Statistics for utilization of storage give the following data for each storage: capacity, average contents, average utilization, number of transactions entering, average time per transaction, current contents, and maximum contents. On page 6.2-5, storage LIBRN, representing subject request processing, has been assigned (by the computer program) a maximum capacity; this is a default since the program does not state a capacity limit. Average contents were 18.433, average utilization was .000, 226 entries passed through, the average time per transaction was 11745 seconds; there are currently 16 transactions in the storage at time of termination of run, and the highest number of transactions in storage at any one time has been 28.

4.5 Savevalue statistics

Statistics for savevalues simply give the value of each savevalue at the time of termination of the run. On page 6.2-5, Savevalue 1 registers 93, the number of requests referred to PNBC; Savevalue 2 register 53, the number of requests for government documents; Savevalue 3 registers 54, the number of requests sent to the Washington Room for processing.

4.6 Queue statistics

Statistics for queues give the maximum contents of the queue, average contents, total entries, the number of entries moving through the queue in a time of zero, the percent of zero-time entries, the average time in queue per transaction, the average time exclusive of zero-time entries, the table number (if any) associated with the queue, and the current contents of the queue. On page 6.2-5, we find that the queue called STK1, which holds those transactions waiting to be searched at the shelves, has had a maximum content of three requests; the average contents have been .488; the total number of transactions passing through the queue have been 667; none have gone through in zero-time; the average time per transaction in queue has been 105.487 seconds, and the average time exclusive of zero-time entries is of course the same 105.487. Table 9 is associated with the queue, and there is currently one transaction waiting in the queue.

One use of the queue statistics is to evaluate the state of the model; if the number of transactions currently waiting in queue is at or near the maximum number that have been in the queue, it is probable that the queue is building and that the flow will be clogged at some future time. An additional facility or storage following the queue will often alleviate the situation--indicating, if the clogged status reflected a real-world bottleneck, the num-

ber of additional workers or machines needed to rectify the procedure. This was the case in earlier runs of MODILIN, when Queue PAK1 (block 48) became overburdened. A second packer (Facility PAKR2) was inserted in the program, bringing the queue-time into reasonable range and lowering the utilization of PAKR, which had been over .95, to the present .604, while PAKR2 was utilized at .445.

4.7 Table statistics

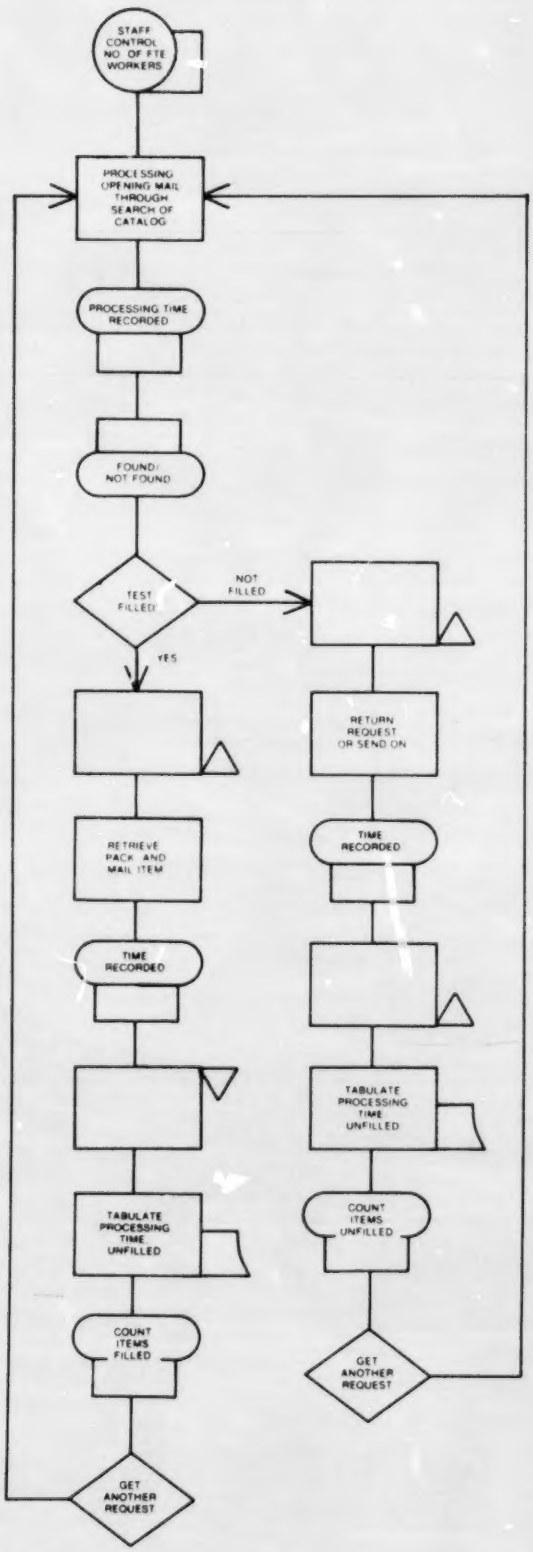
Tables provide frequency distributions of times of flow or other measures for various types of transaction and/or for various segments of the model. Statistics in tables include both nonweighted and weighted values for the number of entries, the mean value of the entries, standard deviation, and sum of the values. Additionally, for each division of the frequency range, the listing includes the frequency, the percent of total entries, the cumulative percentage, cumulative remainder, the class's multiple of the mean, and deviation from mean. On page 6.2-5, Table ATP gives data for the processing time required for requests which are filled. There are 777 filled requests; the mean time per request is 2807.57 seconds; standard deviation is 5904; and the sum of all the times is 2958482 seconds. There are no requests filled in five minutes or less. 568 requests are filled in 2000 seconds or less; this is 73.1% of all filled requests, leaving 26.8 percent which require more than 2000 seconds. The upper limit of this group is .525 of the overall mean, and .306 standard deviations less than the overall mean.

4.8 Conclusion

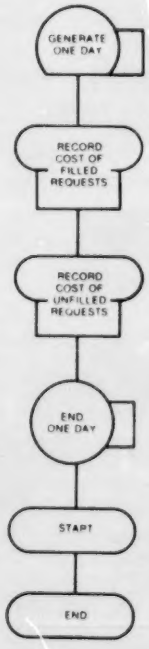
The data derived from these various outputs can be manipulated manually according to the user's needs, based on understanding of the model's premises and structure, and of the model's probability of conformity to aspects of the real world.

5.0 BLOCK DIAGRAMS OF MODELS

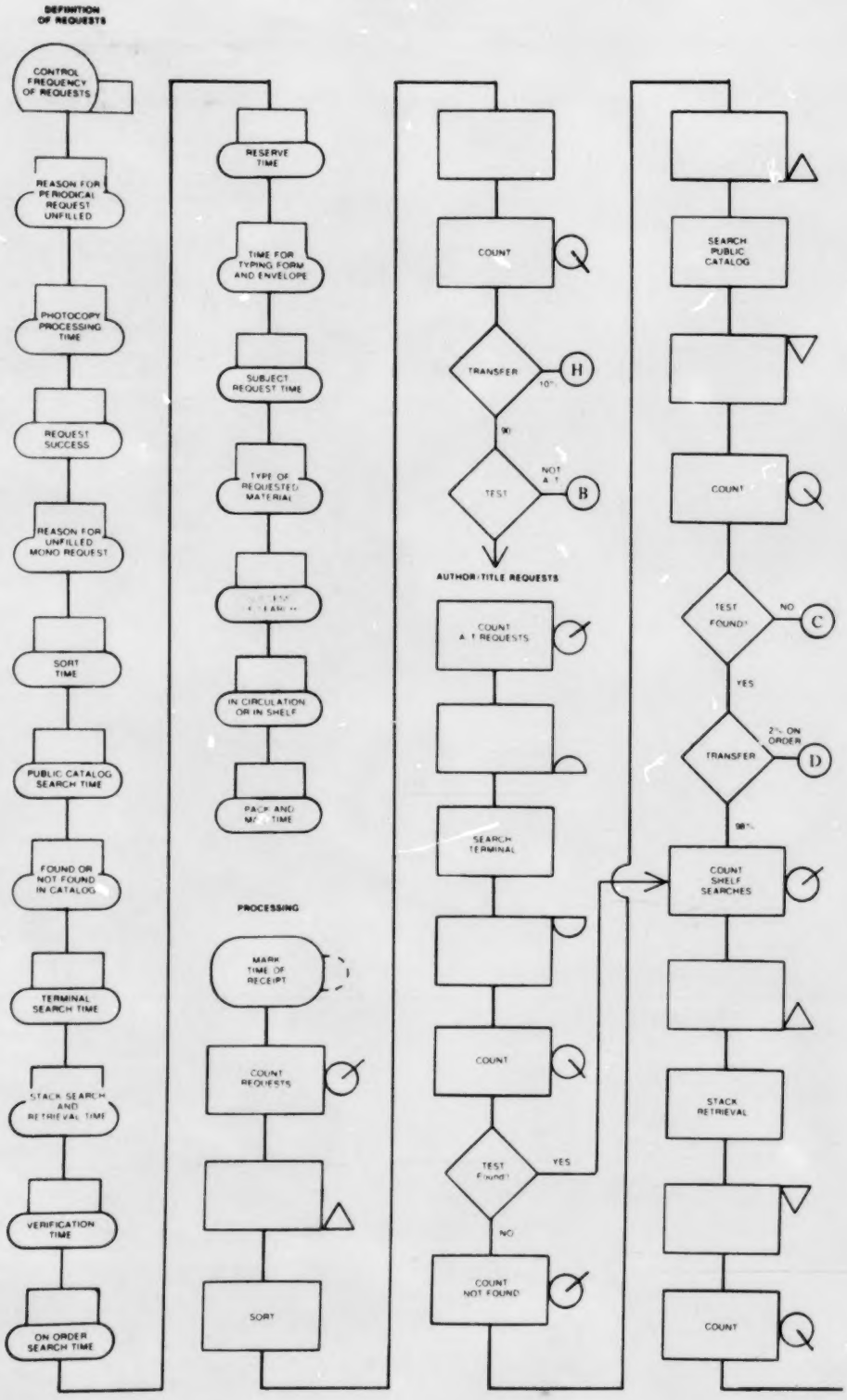
5.1 MODILIN1
BLOCK DIAGRAM

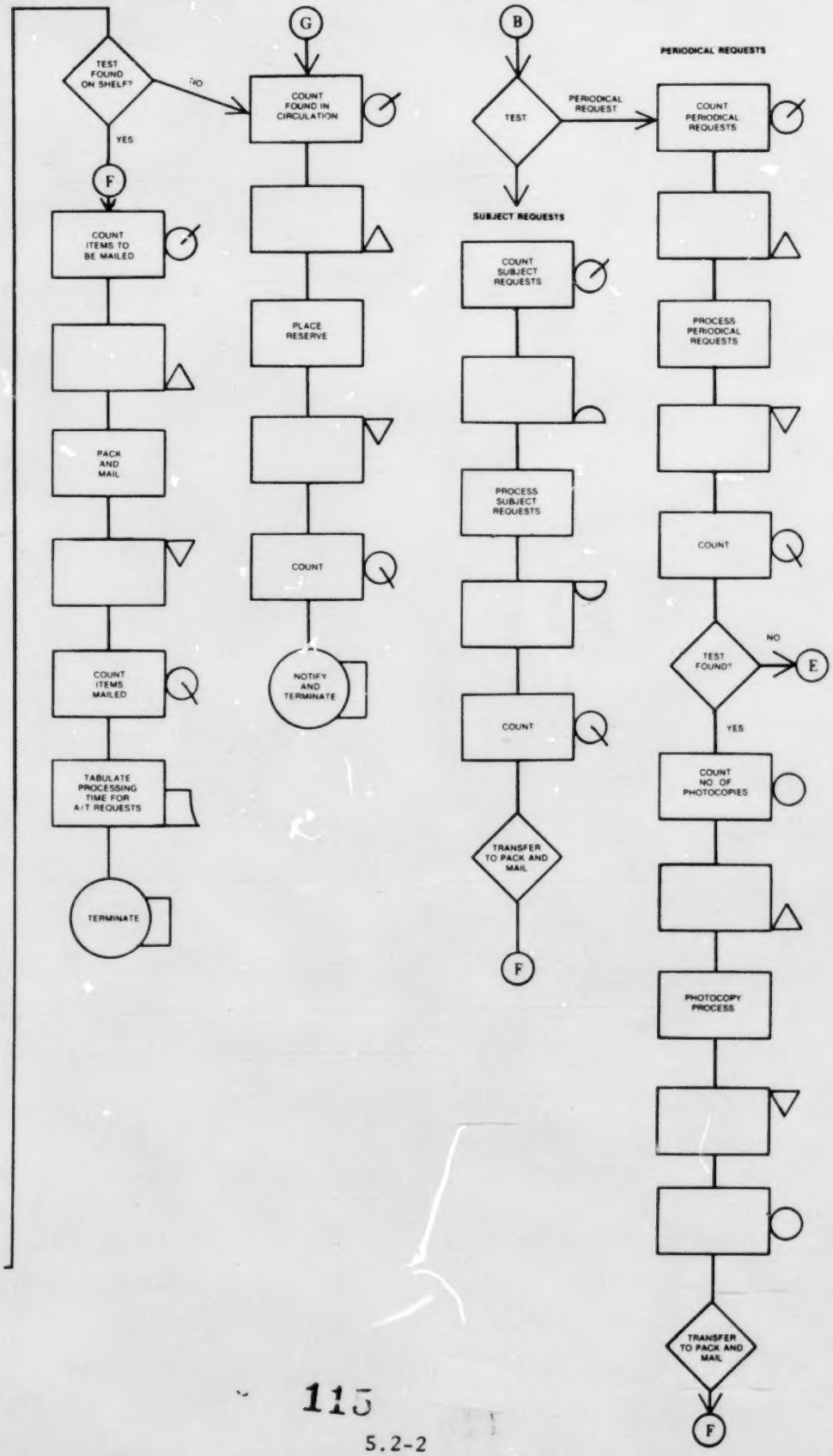


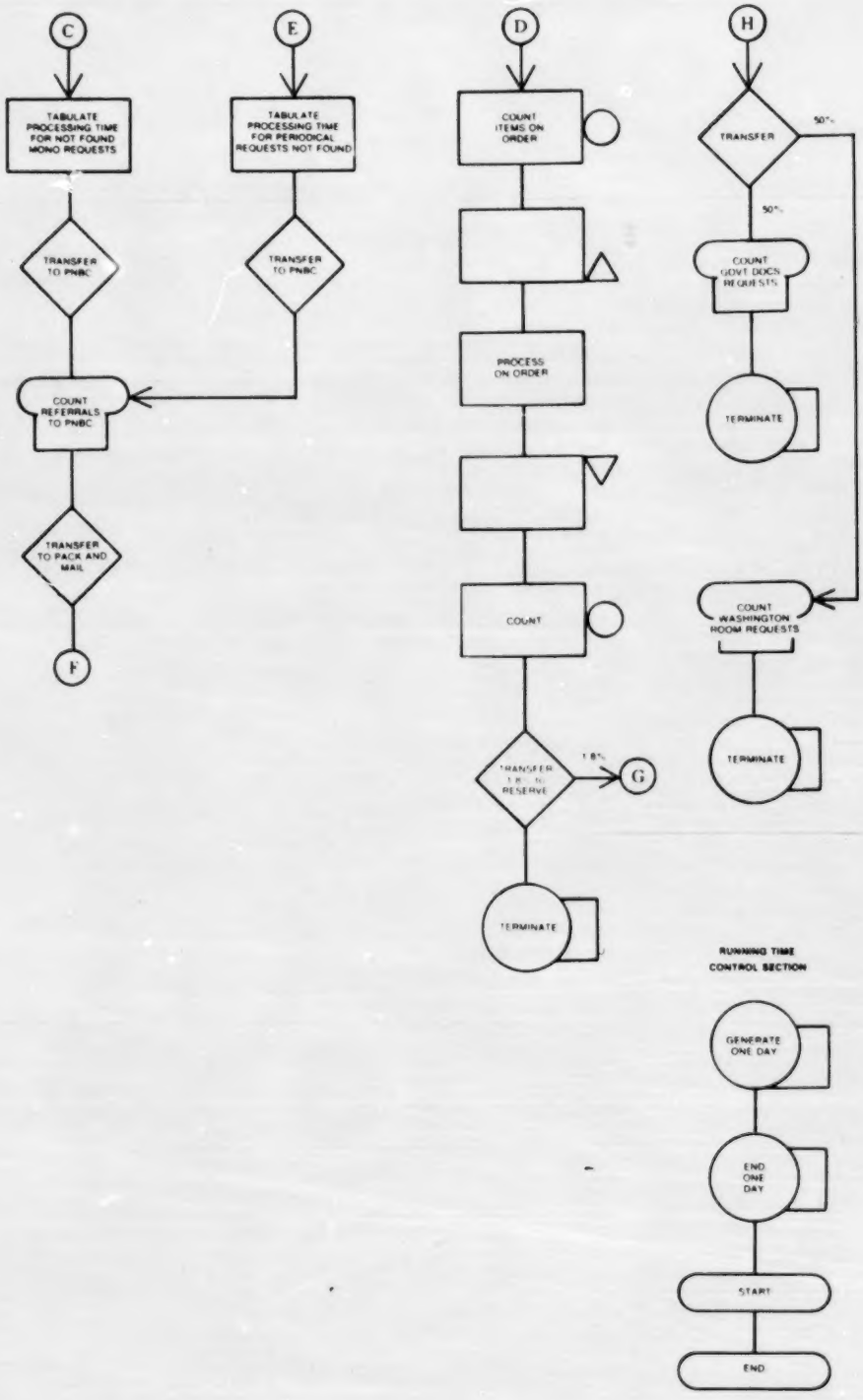
RUNNING TIME SECTION



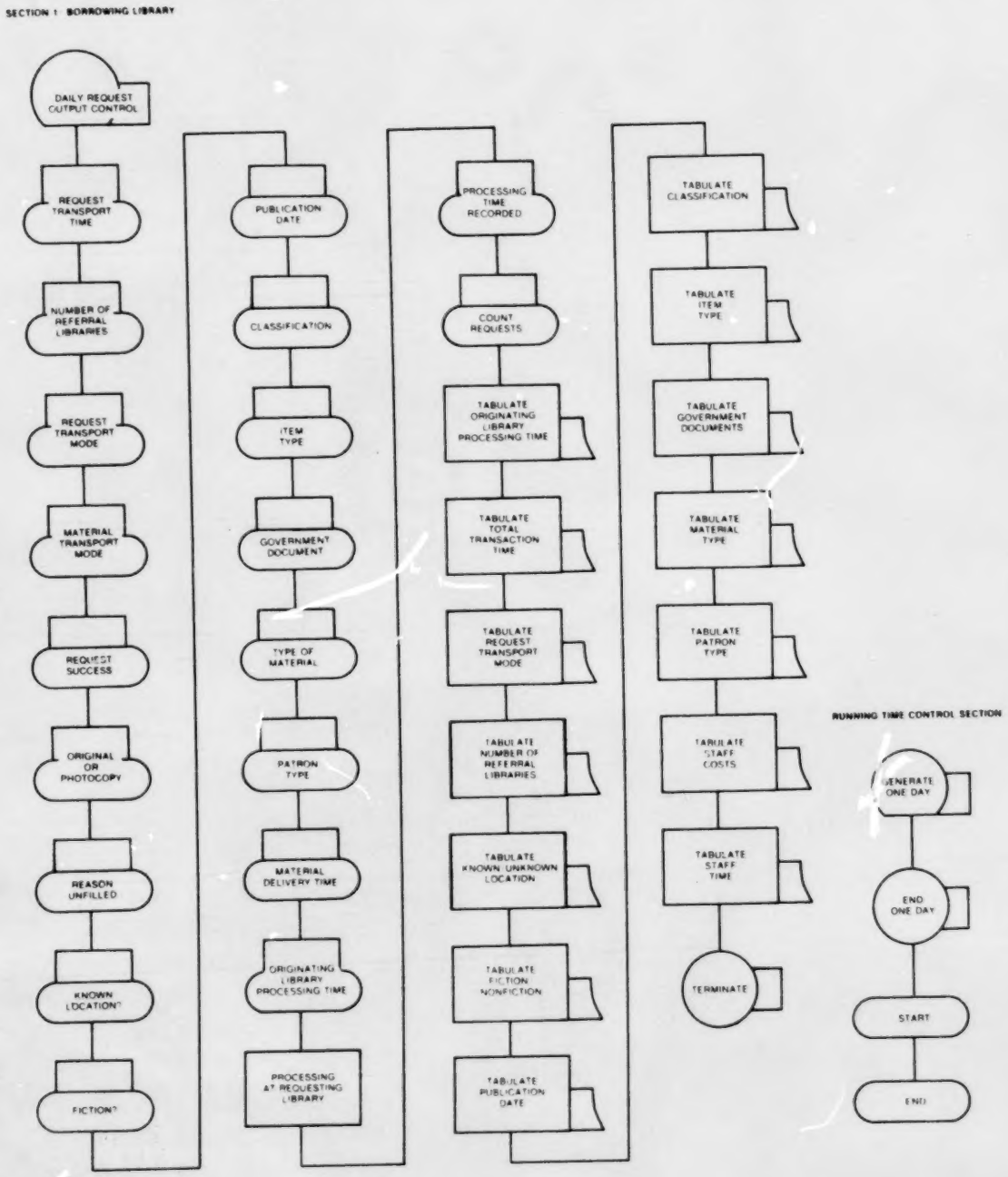
5.2 MODILIN
BLOCK DIAGRAM



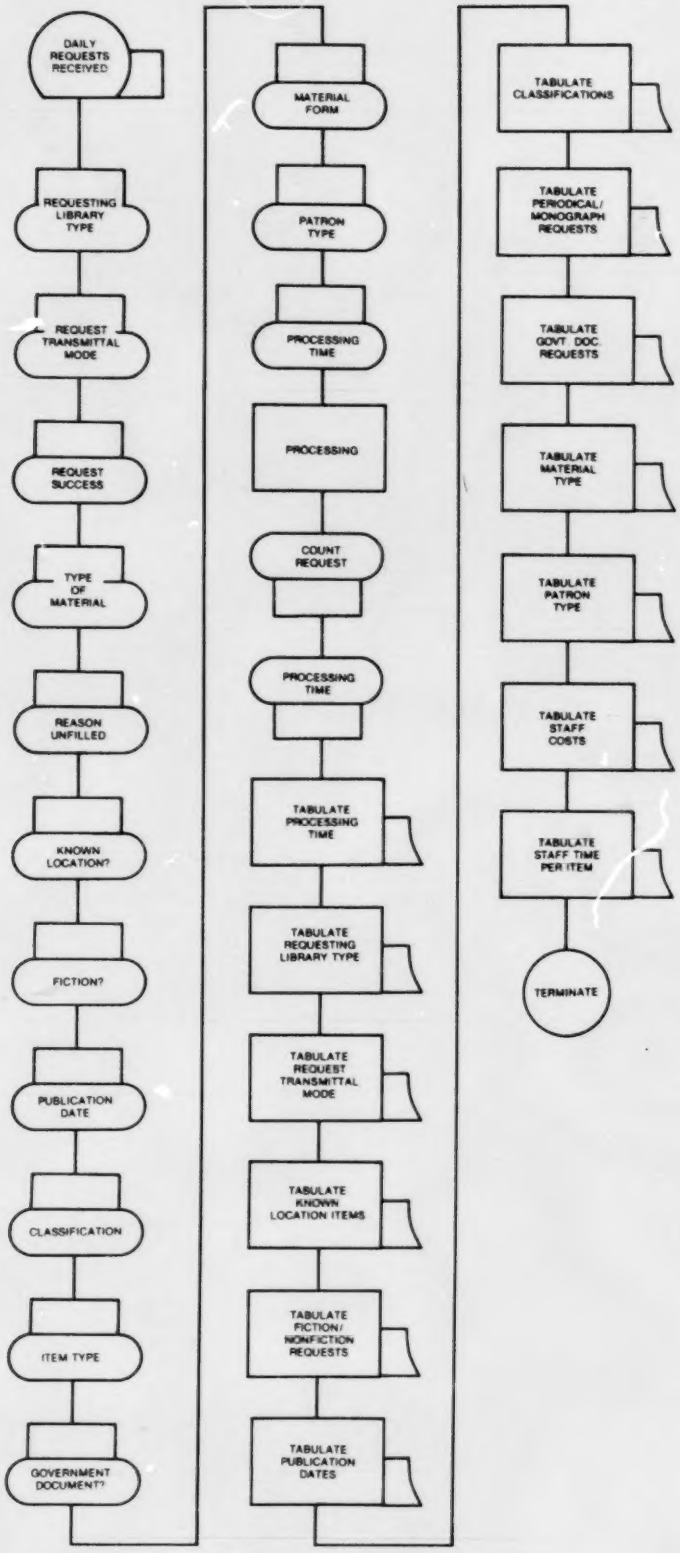

TEST FOUND ON SHELF?
NO
YES
G
COUNT FOUND IN CIRCULATION
PLACE RESERVE
COUNT
NOTIFY AND TERMINATE
F
COUNT ITEMS TO BE MAILED
PACK AND MAIL
COUNT ITEMS MAILED
TABULATE PROCESSING TIME FOR A/T REQUESTS
TERMINATE
B
TEST
PERIODICAL REQUEST
SUBJECT REQUESTS
COUNT SUBJECT REQUESTS
PROCESS SUBJECT REQUESTS
COUNT
TRANSFER TO PACK AND MAIL
F
PERIODICAL REQUESTS
COUNT PERIODICAL REQUESTS
PROCESS PERIODICAL REQUESTS
COUNT
TEST FOUND?
NO
E
YES
COUNT NO OF PHOTOCOPIES
PHOTOCOPY PROCESS
TRANSFER TO PACK AND MAIL
F


C
TABULATE PROCESSING TIME FOR NOT FOUND MONO REQUESTS
TRANSFER TO PNBC
COUNT REFERRALS TO PNBC
TRANSFER TO PACK AND MAIL
F
E
TABULATE PROCESSING TIME FOR PERIODICAL REQUESTS NOT FOUND
TRANSFER TO PNBC
D
COUNT ITEMS ON ORDER
PROCESS ON ORDER
COUNT
TRANSFER TO RESERVE
G
TERMINATE
H
TRANSFER
50%
50%
COUNT GOVT DOCS REQUESTS
TERMINATE
COUNT WASHINGTON ROOM REQUESTS
TERMINATE
RUNNING TIME CONTROL SECTION
GENERATE ONE DAY
END ONE DAY
START
END

5.3 MODILBL
BLOCK DIAGRAM

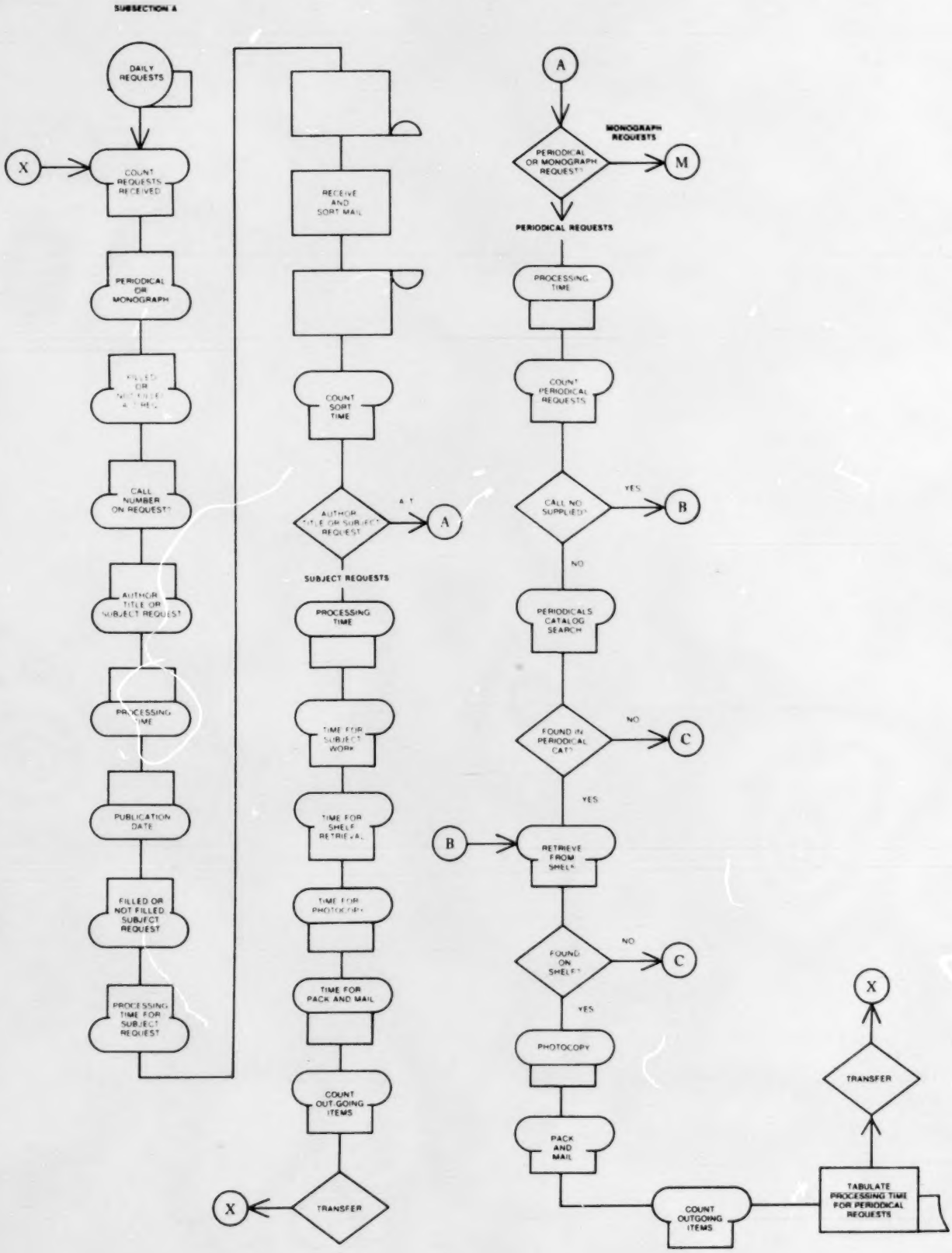


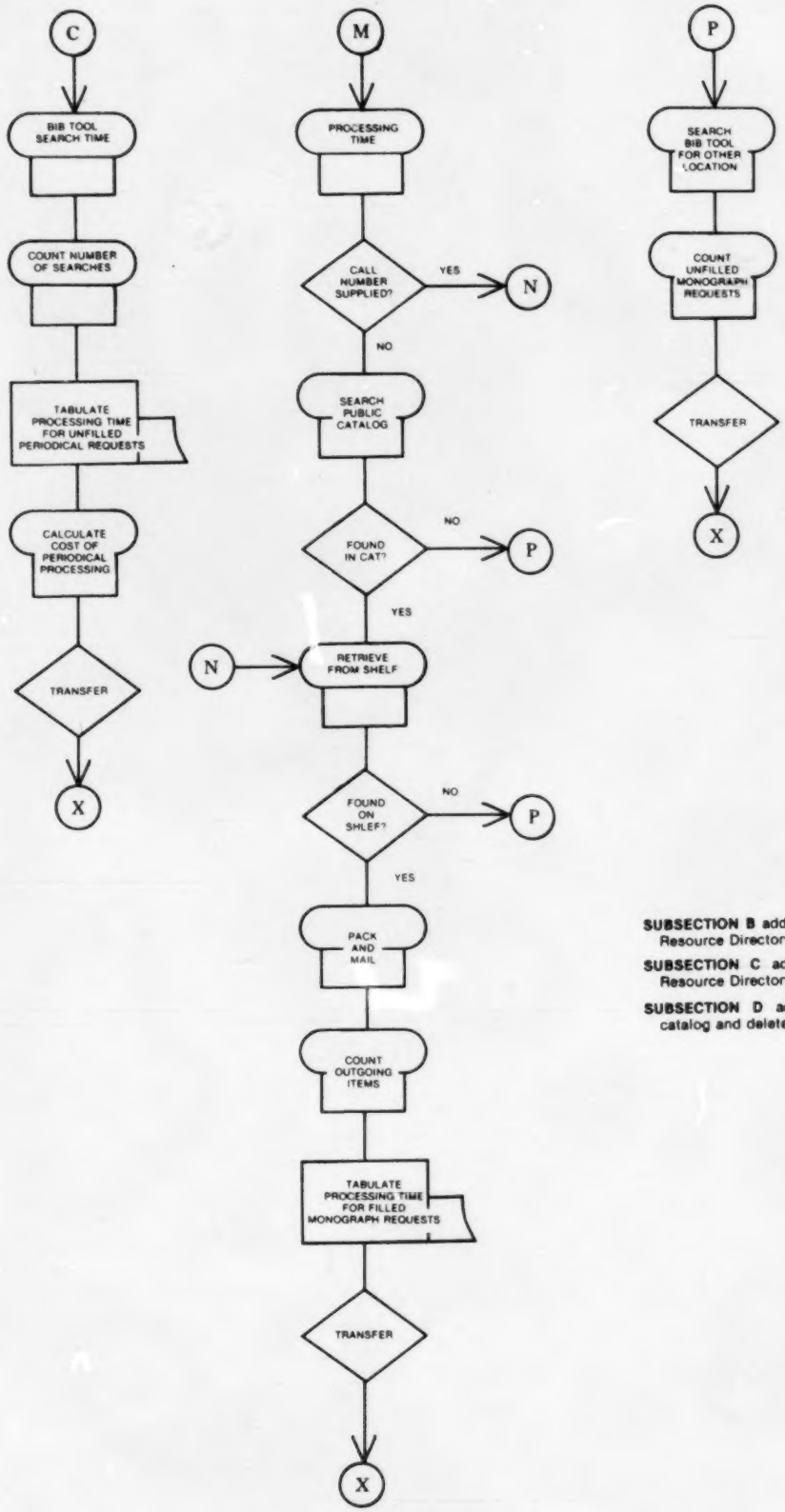
SECTION 3: REQUESTED LIBRARY



RUNNING TIME CONTROL SECTION

5.4 MODILIN2
BLOCK DIAGRAM



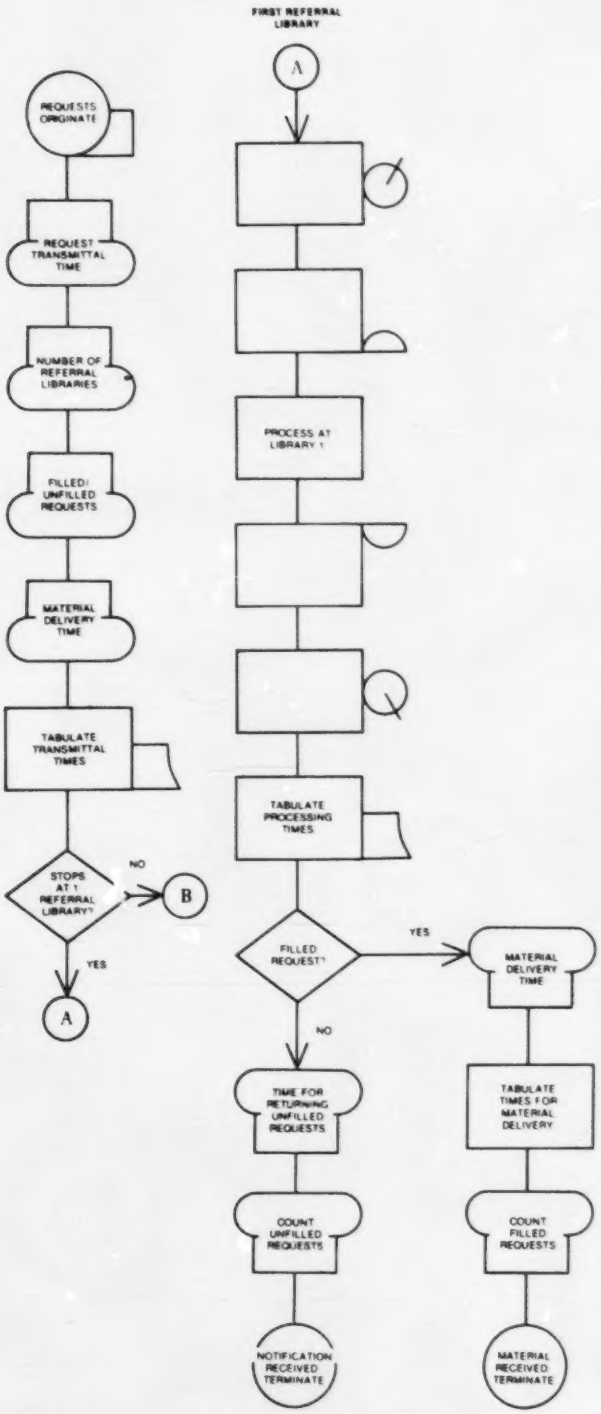


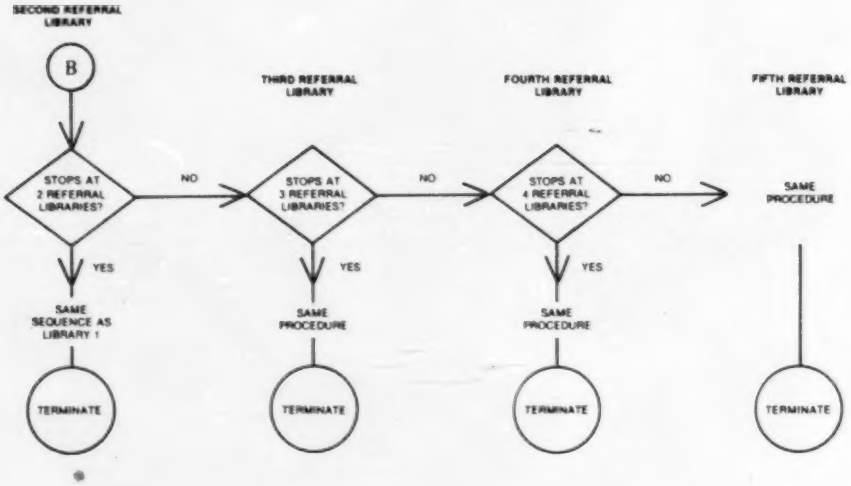
SUBSECTION B adds search in microfiche Resource Directory.

SUBSECTION C adds search in on-line Resource Directory.

SUBSECTION D adds search in union catalog and deletes subject search.

5.5 MODILEX
BLOCK DIAGRAM




SECOND REFERRAL LIBRARY
B
STOPS AT 2 REFERRAL LIBRARIES?
NO
YES
SAME SEQUENCE AS LIBRARY 1
TERMINATE
THIRD REFERRAL LIBRARY
STOPS AT 3 REFERRAL LIBRARIES?
NO
YES
SAME PROCEDURE
TERMINATE
FOURTH REFERRAL LIBRARY
STOPS AT 4 REFERRAL LIBRARIES?
NO
YES
SAME PROCEDURE
TERMINATE
FIFTH REFERRAL LIBRARY
SAME PROCEDURE
TERMINATE